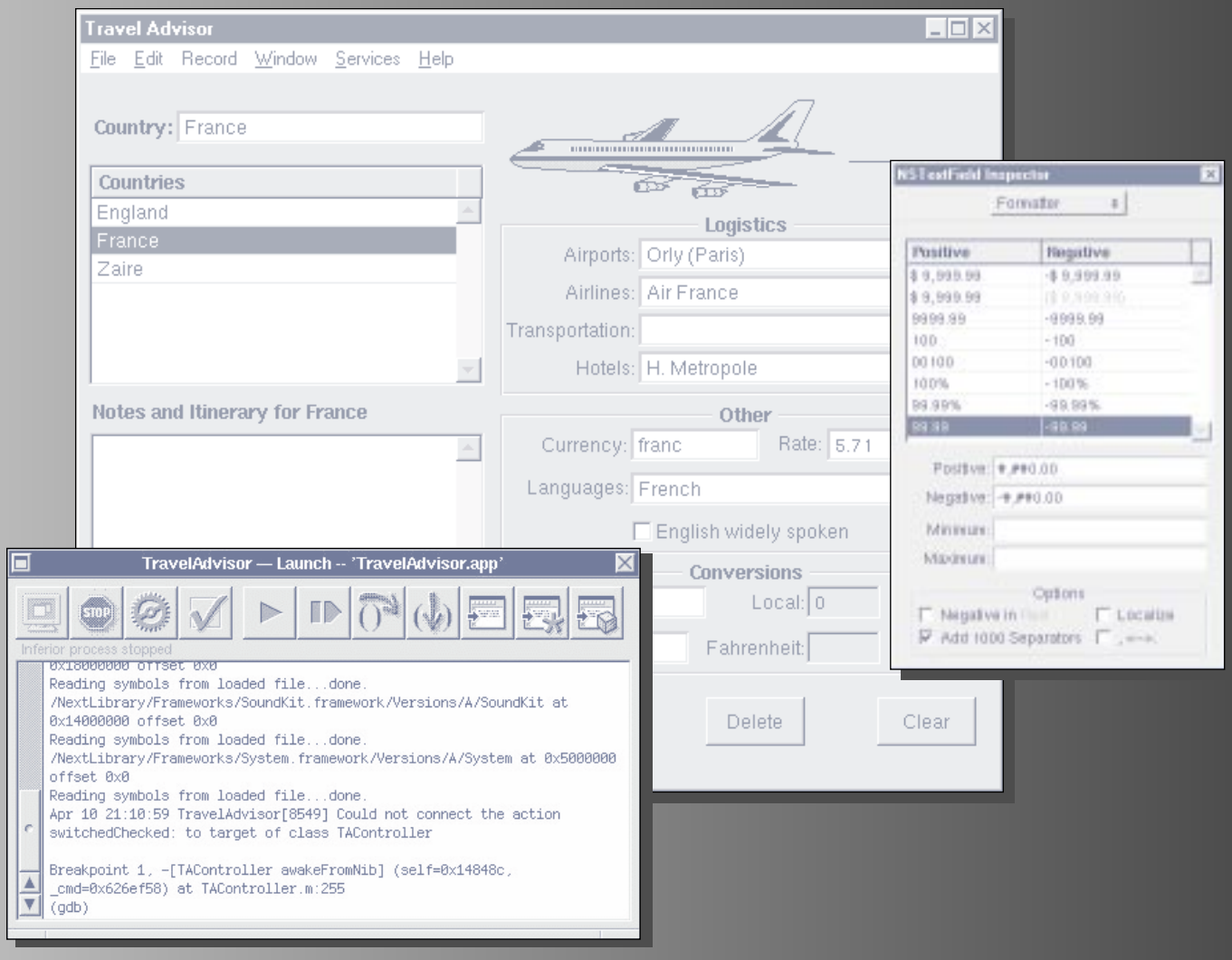
Travel Advisor Tutorial Chapter 3



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Chapter 3
Travel Advisor Tutorial

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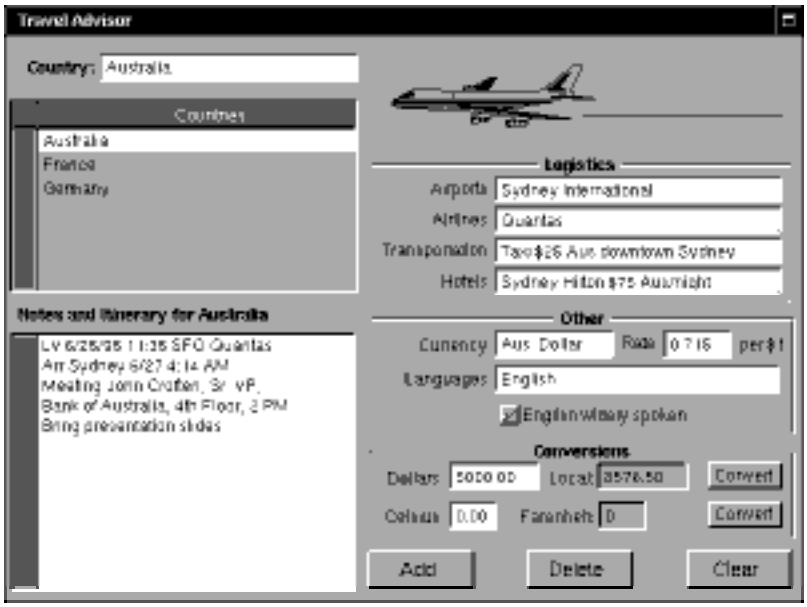
In this chapter you create Travel Advisor, an application that is considerably more complex than the Currency Converter application you built in the first tutorial. Travel Advisor is a forms-based application used for entering, viewing, and maintaining records on countries that the user travels to. Users enter a country name and information associated with that country. When they click Add, the country appears in the table below the country name. They can select countries in the table, and the information on that country appears in the forms. The application also performs temperature and currency conversions.



This chapter presents a lot of information on OpenStep programming. Among other things, you'll learn how to:

- Use several new objects on Interface Builder's palettes.
- Assign an icon to an application.
- Print the contents of a view.
- Use collection objects (NSArray and NSDictionary).
- Use string objects (NSString).
- Archive and unarchive object data.
- Format and validate field contents.
- Manage events through delegation.
- Quickly find information related to your project.
- Use Project Builder's graphical debugger.

Perhaps most interestingly, you will *reuse* the Converter class you implemented in the previous tutorial.

Collection objects allow you to store, organize, and access data in different ways. For more information, see "The Collection Classes" on page 74.

String objects represent textual strings in various encodings. See page 82 for more information.

You can find the TravelAdvisor project in the **AppKit** subdirectory of **/NextDeveloper/Examples**.

Creating the Travel Advisor Interface

1 **Create the application project.**

Start Project Builder.

Choose New from the Project menu.

Name the application "TravelAdvisor."

2 **Open the application's nib file.**

Click Interfaces in the project browser, select **TravelAdvisor.nib**, and double-click its icon.

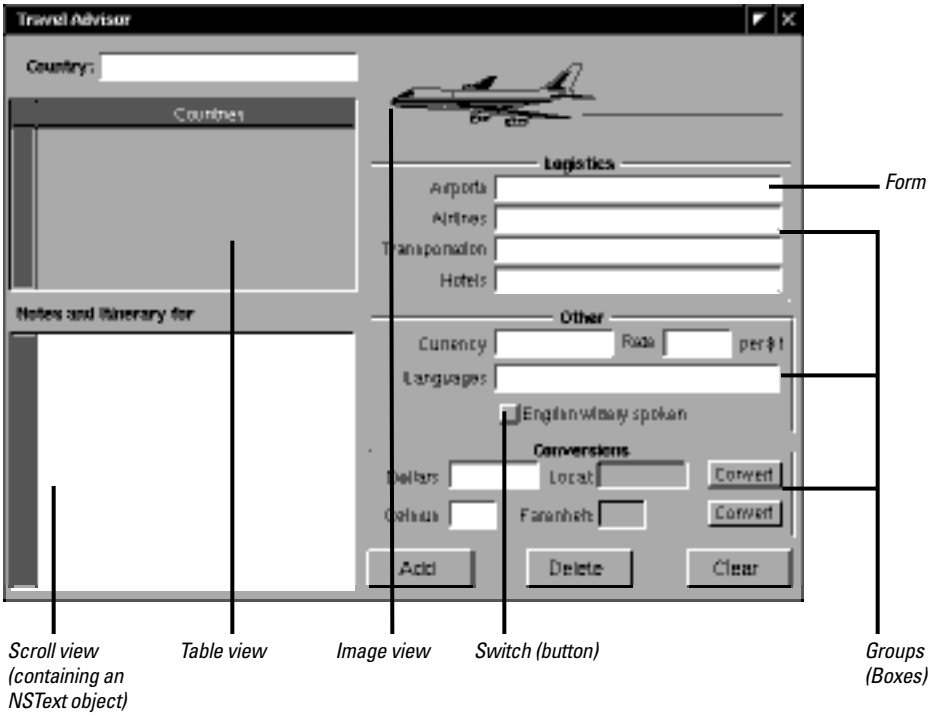
3 **Customize the application's window.**

Resize the window, using the example at right as a guide.

In the Attributes display of the Inspector panel, entitle the window "Travel Advisor."

Turn off the resize bar.

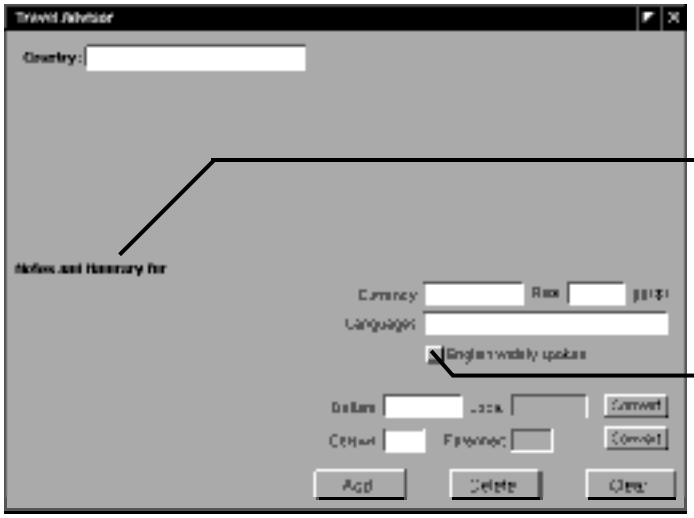
You should be familiar with many of the objects on the Travel Advisor interface because you've encountered them in the Currency Converter tutorial. The following illustration points out the objects that are new to you in this tutorial.



The following pages describe the purpose of each new object found on Interface Builder's palettes and explain how to set these objects up for Travel Advisor. Before getting to these new objects, start with the familiar ones: buttons and text fields.

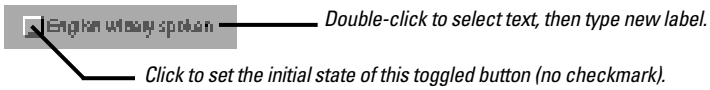
4 **Put the text fields, labels, and buttons on the window.**

Position, re-size, and initialize the objects as shown.



You might think the "English widely spoken" object is a new kind of object. It's actually a button, a special style of button called a switch.

Set up the switch.



Varieties of Buttons

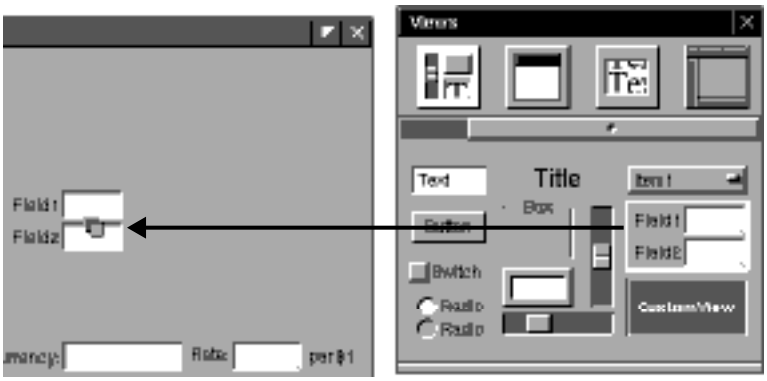
If in Interface Builder you select the "English widely spoken" switch and bring up the Attributes inspector, you can see that the switch is a button set up in a special way.

Buttons are two-state control objects. They are either off or on, and this state can be set by the user or programmatically (**setState:**). For certain types of buttons (especially standard buttons like Currency Converter's Convert button), when the state is switched, the button sends an action message to a target object. Toggle-type buttons—such as switches and radio buttons— visually reflect their state. Applications can learn of this state with the **state** message. You can make your own buttons, associating icons and titles with a button's off and on states, and positioning title and icon relative to each other.

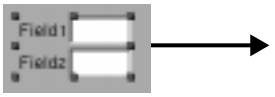
Construct the "Logistics" section of the interface using a form object.

5 **Place a form on the interface and prepare it.**

Drag the form object from the Views palette.

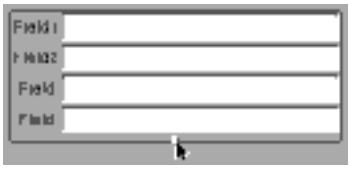


Increase the size of the form's fields by dragging the middle resize handle sideways.



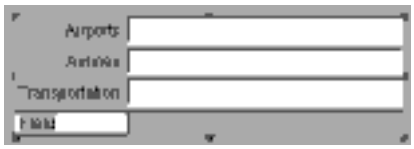
Drag to lengthen the fields.

Create two more form fields by Alternate-dragging the bottom-middle resize handle downward.



As you Alternate-drag, new form fields appear underneath the cursor.

Rename the field labels.



Double-click to select label text.

Type the new label text and click outside the form to set the text.

More About Forms

Forms are labelled fields bound vertically in a matrix. The fields are the same size and each label is to the left of its field. Forms are ideal objects for applications that display and capture multiple rows of data, as do many corporate client-server applications.

The editable fields in a form are actually cells that you programmatically identify through zero-based indexing; the first cell is at index 0 of the matrix, the second cell at index 1, and so on. NSForm defines the behavior of forms; individual cells are instances of NSFormCell. Access these cells with NSForm's **cellAtIndex:** method.

Form Attributes

In addition to the obvious controls in the Forms inspector, there's the "Cell tags = positions" attribute. Switching this on assigns tags to each NSFormCell that correspond to the cells' indices. (A tag is a number assigned to an object that is used to idenitfy and access that object. You'll use tags extensively in the next tutorial.)

The Scrollable option, turned on by default, enables the user to type long entries in fields, scrolling contents to the left as characters are entered.

To make titled sections of the fields, forms, and buttons on the Travel Advisor interface, group selected objects. By grouping them, you put them in a box.

6 **Group the objects on the interface.**

Select the two Convert buttons and the Dollars, Local, Celsius, Fahrenheit labels and text fields.

Choose Format ► Group ► Group in Box.

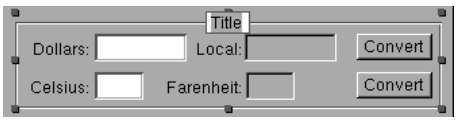
Double-click "Title" to select it.

Choose Format ► Font ► Bold to make the title bold face.

Rename "Title" to "Conversions."

Repeat for the next two groups: "Logistics" and "Other."

To select the objects as a group, drag a selection rectangle around them or Shift-click each object. (To make a selection rectangle, start dragging from an empty spot on the window.)



After you choose the Group in Box command, the objects are enclosed by a titled box.

Boxes are a useful way to organize and name sections of an interface. In Interface Builder you can move, copy, paste, and do other operations with the box as a unit. For Travel Advisor, you don't need to change the default box attributes.

Before You Go On

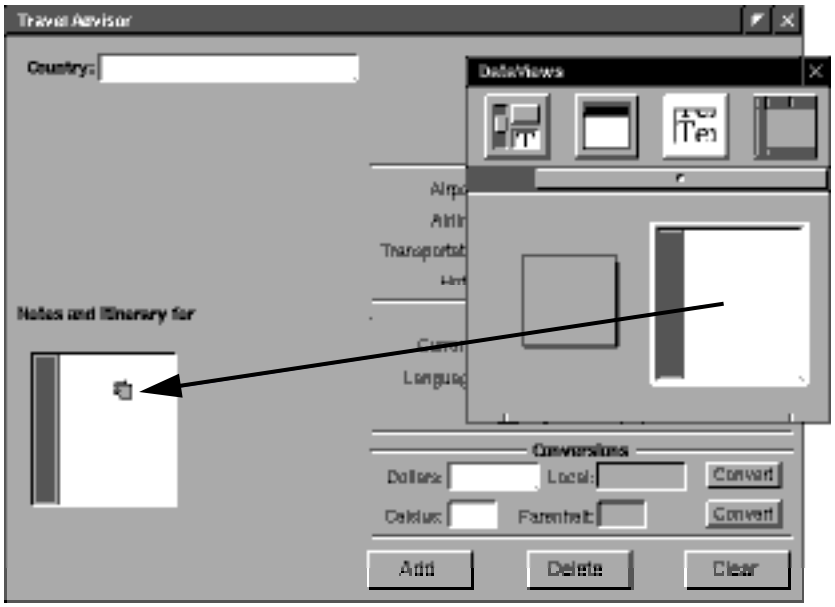
Programmatically, the box is the *superview* of all of its grouped objects. (A *view*, simply put, is any object visible on a window.) A superview encloses its *subviews* and is the next in line to respond to user actions if none of its subviews cannot handle them.

The scroll view on the DataViews palette encloses a text object (an instance of NSText). This object allows users to enter, edit, and format text with minimal programmatic involvement on your part.

7 **Put the scroll view on the window and resize it.**

Drag the scroll view from the DataViews palette and drop it on the lower-left corner of the window.

Resize the scroll view..



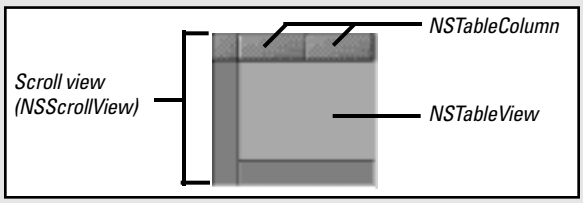
You don't need to change any of the default attributes of the scroll view (but you might want to look at the attributes you can set, if you're curious).

Next, add a table view for displaying the list of countries.

More About Table Views

A table view is an object for displaying and editing tabular data. Often that data consists of a set of related records, with rows for individual records and columns for the common fields (attributes) of those records, Table views are ideal for applications that have a database component, such as Enterprise Objects Framework applications.

The table view on Interface Builder's TabulationViews palette is actually several objects, bound together in a scroll view. Inside the scroll view is an instance of NSTableView in which data is displayed and edited. At the top of the table view is an NSTableHeaderView object, which contains one or more column headers (instance of NSTableColumn).



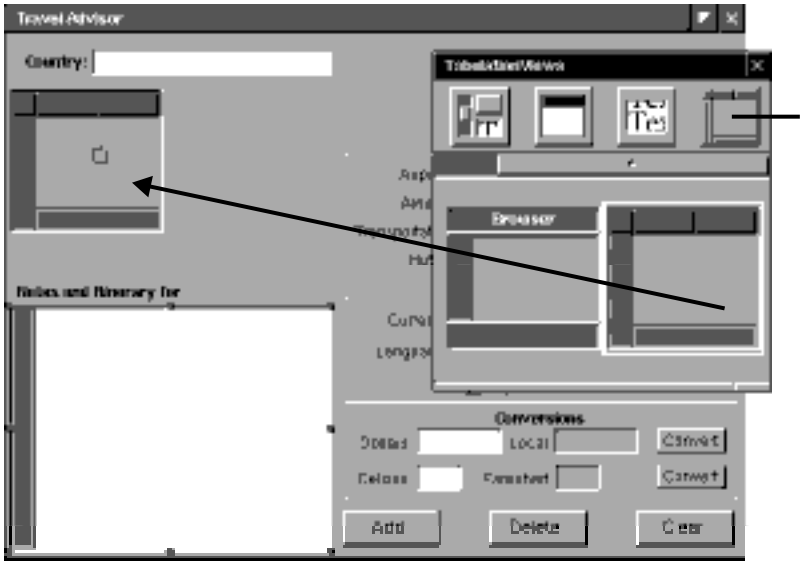
Later in this tutorial you will learn some basic techniques for accessing and managing the data in a table view. Here's a quick preview of the essential pieces:

- **Data source**. The data source is any object in your application that supplies the NSTableView with data. The elements of data (usually records) must be identifiable through zero-based indexing. The data source must implement some or all of the methods of the NSTableDataSources informal protocol.
- **Column identifier**. Each column (NSTableColumn) of a table view has an identifier associated with it, which can be either an NSString or a number. You use the identifier as a key to obtain the value of a record field.
- **Delegate methods**. NSTableView sends several messages to its delegate, giving it the opportunity to control the appearance and accessibility of individual cells, and to validate or deny editing in fields.

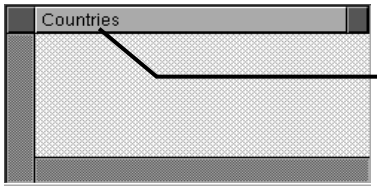
8 **Place and configure the table view.**

Drag the table view object from the TabulationViews palette.

Resize the table view.



Set the title of the first column to "Countries."



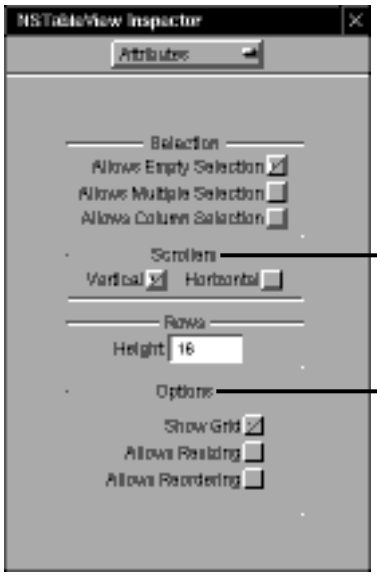
Make the table header only one column.

The other object on the TabulationViews palette is a *browser*. It is just as suitable for the Travel Advisor application as a table view. Browsers are ideal for displaying hierarchically structured information (such as is found in the UNIX file system) as well as single-level views of data such as the list of countries in Travel Advisor. A table view can also handle single-column rows of data easily; it is used instead because it is designed for displaying and editing records from relational databases, something that Enterprise Objects Framework (EOF) programmers find very useful .

To configure the table view, you must set attributes of two component objects: the NSTableView object and the NSTableColumn object.

Select the NSTableView by double-clicking the interior of the table view.

Set the attributes as shown at right.



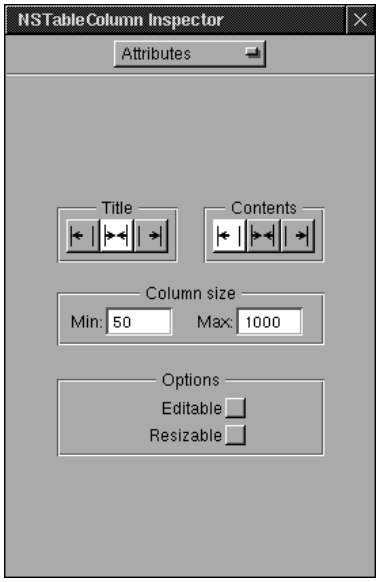
Since this is a single-column view and country names are of limited length, you need only the verticle scroller, in case there's no more countries that can be shown at once.

Whether to show the grid is a matter of personal preference, but turn off resizing and reordering. The user shouldn't be able to affect the contents of the column directly.

The Attributes display for NSTableView is the same as that for NSScrollView.

Select the column by double-clicking once (if this inserts the cursor, click outside the column, then click the column once).

Set the NSTableColumn attributes as shown at right.



The Travel Advisor window is nearly complete. For a decorative touch, you're next going to add an image to the interface.

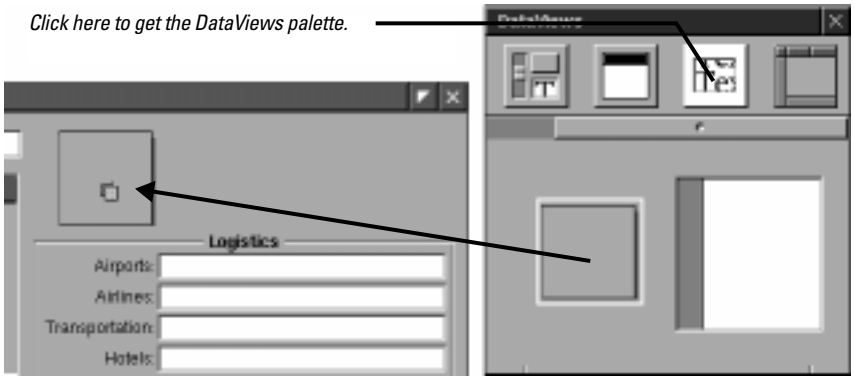
9 **Add an image to the interface.**

Drag the image view onto the window, as shown at right.

In Project Builder:

Double-click Images in the project browser.

In the Open panel, select the file **Airline.eps** from the **/AppKit/TravelAdvisor** subdirectory of **/NextDeveloper/Examples**



Before You Go On

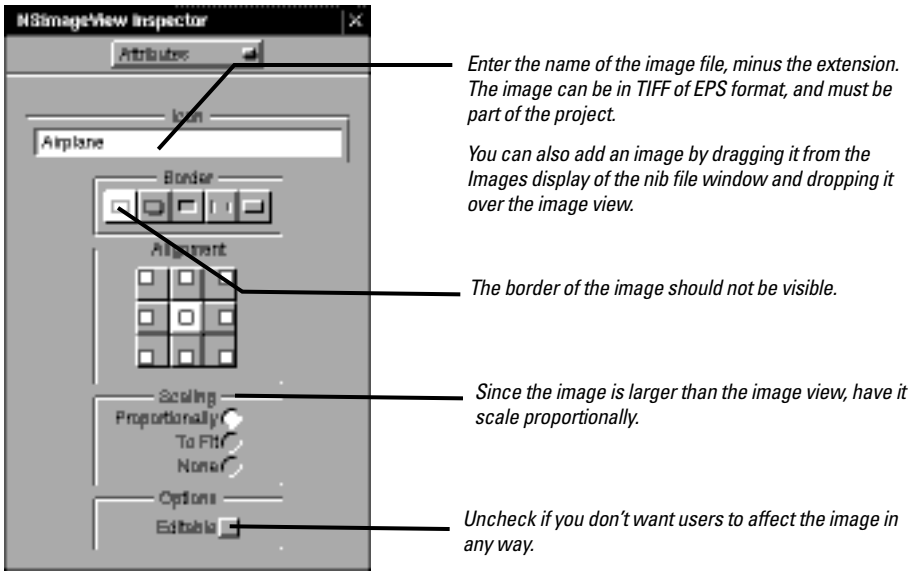
Sometimes buttons are the preferred objects for holding images—for instance when you want a different image for either state of a button. But when buttons are disabled, any image they display is dimmed. So for decorative images, use image views (NSImageView) instead of buttons.

When you drop a sound or image over a button or image view, it is added to the nib file. When you add an image or a sound to a nib file, Interface Builder asks if you also want to add the resource to the project. Nib files are localized and their resources are only accessible when the nib file has been loaded. Resources that are associated with a project *can* be localized and are always accessible.

In the Attributes inspector for the image view, type the name of the image and set the NSImageView attributes.

Make the image view (and the enclosed image) small enough to fit between the title bar and the Logistics group.

Add a "velocity" line behind the airplane.



Tip: To make the "velocity" line behind the airplane, make a title-less black box with a vertical offset of zero, and run the top and bottom lines together.

Travel Advisor's main menu has a submenu and a command that do not come ready-made on the Menus palette. You use the Submenu and the Item cells to create customized submenus and menu commands, respectively.

10 **Add commands to the main menu.**

Select the Menus palette.

Drag the Item command and drop it between Edit and Services.

Change "Item" to "Print Notes...".

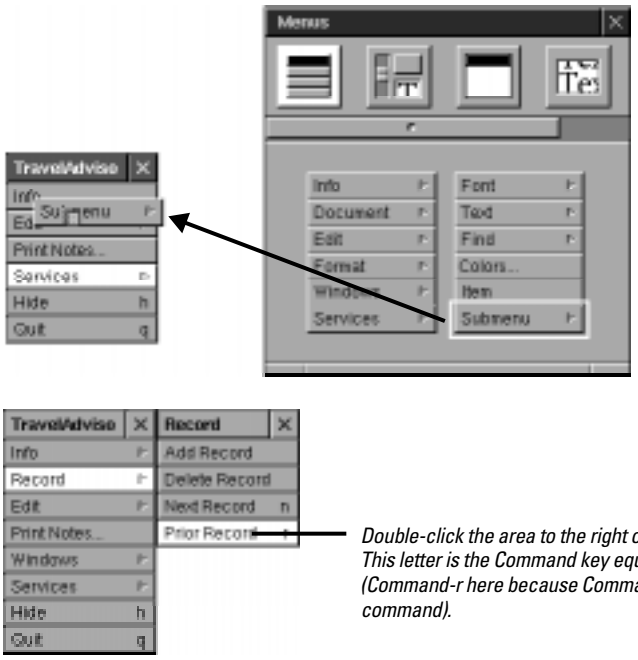
Drag the Submenu item and drop it between Info and Edit.

Double-click Submenu to select the item text; change the name to "Records".

Add three Items to the Records submenu (making four altogether).

Change the command names to those shown at right.

Add key equivalents to the right of the last two commands.



Double-click the area to the right of the command and type a letter. This letter is the Command key equivalent to teh menu command (Command-r here because Command-p is often reserved for a print command).

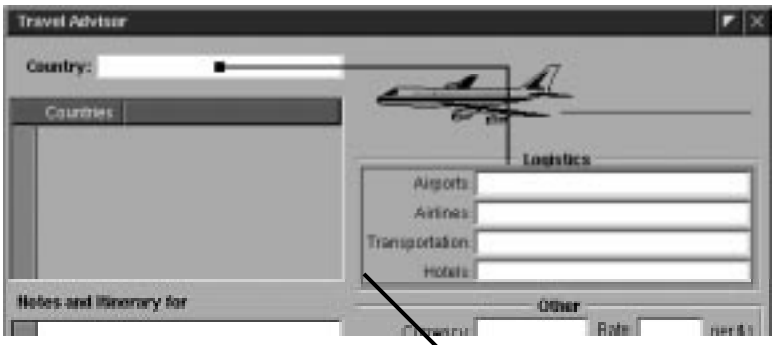
Three dots after a menu command indicates that the command opens a panel: "Print Notes..." means that clicking this command displays the Print panel.

You can now connect many of the objects on the Travel Advisor interface through outlets and actions defined by the Application Kit. As you might recall, text fields have a **nextKeyView** outlet that you connect so that users can tab from field to field. Forms also have a **nextKeyView** outlet for tabbing. (The fields within a form are already interconnected, so you don't need to connect them.)

11 **Connect Application Kit outlets for inter-field tabbing and printing.**

In top-to-bottom sequence, connect the fields and the form through their **nextKeyView** outlets.

When you reach the Languages field, connect it with the Country field, making a loop.



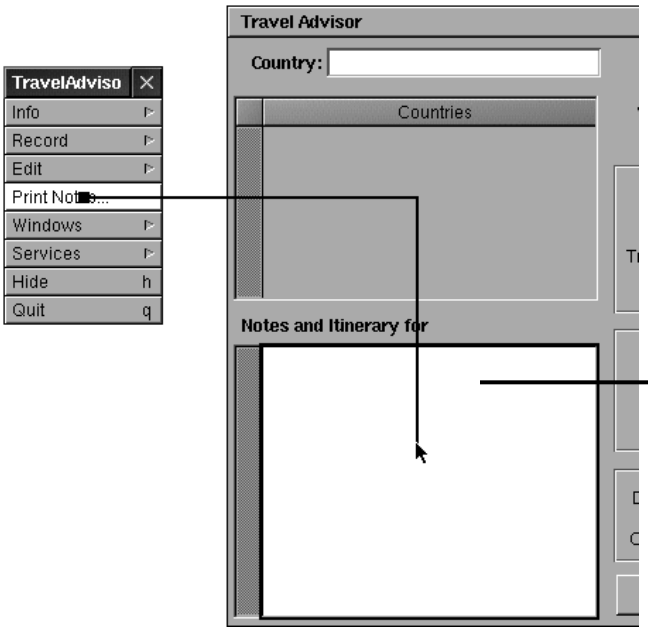
*When a gray line borders the form, it is selected. Release the mouse button and set the **nextkeyview** outlet connection.*

The Application Kit also has "pre-set" actions that you can connect your application to. The NSText object in the scroll view can print its contents as can all objects that inherit from NSView. To take advantage of this capability, "hook up" the menu command with the NSText action method for printing.

Connect the Print Notes menu command to the text object in the scroll view.

Select the **print:** action method in the Connections display of the Inspector panel.

Click the Connect button in the Inspector's Connection display.



Make sure the text object (the white rectangle) is selected and not the scroll view that encloses it.

The final step in crafting the Travel Advisor interface has nothing to do with the main window, but with what users see of your application when they encounter it in the File Manager: the application's icon.

12 **Add the application icon.**

In Project Builder:

Open the Project Inspector.

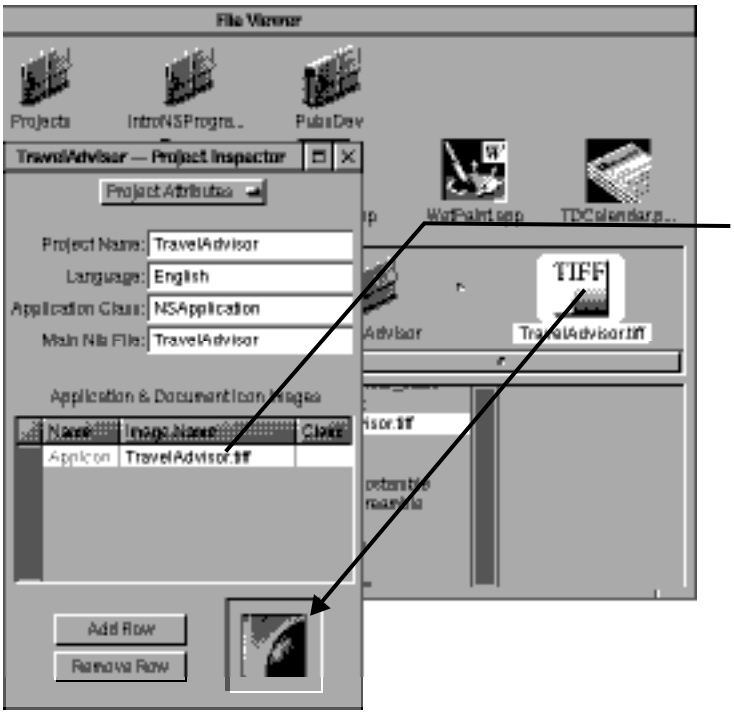
Go to the Project Attributes display of the inspector.

Click in the Application Icon field.

In File Manager

Locate **TravelAdvisor.tiff** in the **/AppKit/TravelAdvisor** subdirectory of **/NextDeveloper/Examples.**

Drag **TravelAdvisor.tiff** into the icon well in the Project Attributes display.



Make sure the cursor is in this field before dragging.

After you drag the image into the well, the icon is displayed in the well and the image file is automatically added to the project.

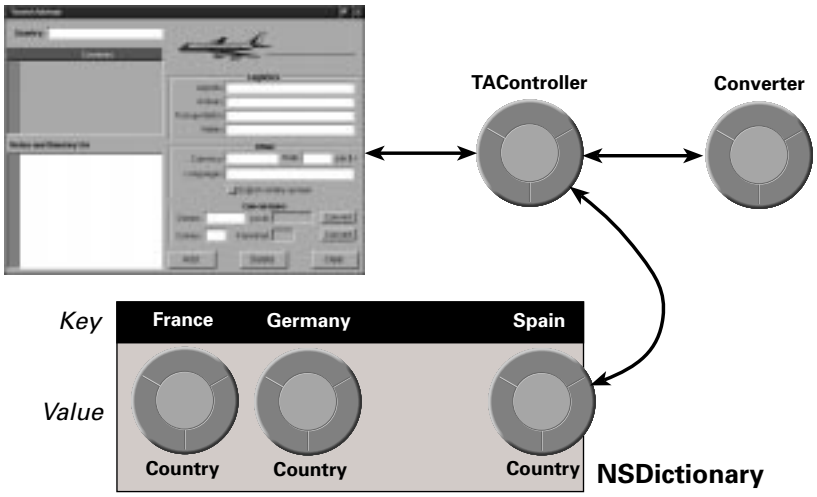
13 **Test the interface.**

You're finished with the Travel Advisor interface. Test it by choosing Test Interface from Interface Builder's Document menu.Try the following:

- Press the Tab key repeatedly. Notice how the cursor jumps between the fields of the form, and how it loops from the Languages field to the Country field. Press Shift-Tab to make the cursor go in the reverse direction.
- Enter some text in the scroll view, then click the Print Notes menu item. The print panel is displayed. Print the text object's contents.
- Also in the scroll view, press the Return key repeatedly until a slider appears in the scroller.

The Design of Travel Advisor

Travel Advisor is much like Currency Converter in its basic design. Like Currency Converter, it's based on the Model-View-Controller paradigm. A controller object (TAController) manages a user interface comprised of Application Kit objects. Also as before, the controller sends a message to the Converter object to get the result of a computation. In other words, the Converter object is reused.



Travel Advisor's view objects, in terms of Model-View-Controller, are all off-the-palette Application Kit objects, so the following discussion concentrates on those parts of the design distinctive to Travel Advisor.

Model Objects

Travel Advisor's design is more interesting and dynamic than Currency Converter's because it must display a unique set of data depending on the country the user selects. To make this possible, the data for each country is stored in a Country object. These objects encapsulate data on a country (in a sense, they're like records in a relational database). The application can manage potentially hundreds of these objects, tracking each without recourse to a "hardwired" connection.

Another model object in the application is the instance of the Converter class. This instance does not hold any data, but does provide some specialized behavior.

Controller

The controller object for the application is TAController. Like all controller objects, TAController is responsible for mediating the flow of data between the user interface (the View part of the paradigm) and the model objects that encapsulate that data: the Country objects. Based on user choices in the interface, TAController can find and display the requested Country object; it can also save changes made by users to the appropriate Country object.

What makes this possible is an NSDictionary object (called a *dictionary* from here on). A dictionary is a container that stores objects and permits their retrieval through key-value associations. The key is some identifier paired with an object in the dictionary (the object often holds the identifier as one of its instance variables). To get the object, you send a message to the dictionary using the key as an argument (**objectForKey:**).

```
NSColor *aColor = [aDictionary objectForKey:@"BackgroundColor"];
```

A Country object holds the name of a country as an instance variable; this country name also functions as the dictionary key. When you store a Country object in the dictionary, you also store the country name (in the form of an NSString) as the object's key. Later you retrieve the object by sending the dictionary the message **objectForKey:** with the country name as argument.

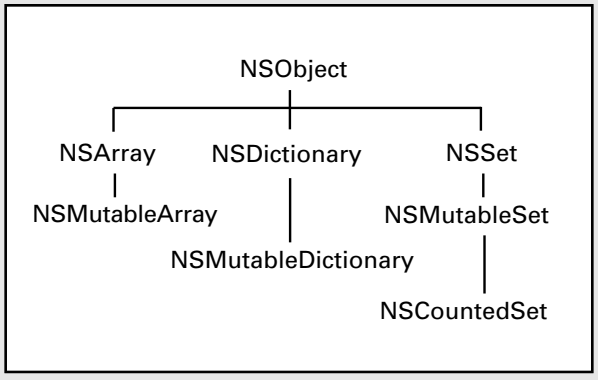
The Collection Classes

Several classes in OpenStep's Foundation Framework create objects whose purpose is to hold other objects. These collection classes are very useful. Instances of them can store and locate their contents through a number of mechanisms.

- Arrays (NSArray) store and retrieve objects in an ordered fashion through zero-based indexing.
- Dictionaries (NSDictionary) store and quickly retrieve objects using key/value pairs. For example, the key "red" might be associated with an NSColor object representing red.
- Sets (NSSet) are unordered collections of distinct elements. Counted sets (NSCountedSet) are sets that can contain duplicate (non-distinct) elements; these duplicates are tracked through a counter. Use sets when the speed of membership-testing is important.

The mutable versions of these classes allow you to add and remove objects programmatically after the collection object is created (see "Abstract Classes and Class Clusters" on page 101).

Collection objects also provide a valuable way to store data. When you store (or *archive*) a collection object in the file system, its constituent objects are also stored.



Storing Data Source Information

See "Implementing the TAController Class" on page 90 for a diagram that depicts the data relationships of TAController as data source. See page 66 for more on NSTableView's data source.

TAController also manages the data source for the table view on the interface. It stores the keys of the dictionary in an array object (NSArray), sorted alphabetically. When the table view requests data, the TAController "feeds" it the objects in the array.

Creation of Country Objects

Another important point of design is the manner in which the Country objects are created. Instead of Interface Builder creating them, the TAController object creates Country objects in response to users clicking the Add button.

Delegation and Notification

See "Getting in on the Action: Delegation and Notification" on page 97 for more on delegation.

An essential aspect of design not evident from the diagram are the roles *delegation* and *notification* play. The TAController object is the delegate of the application object and thereby receives messages that enable it to manage the application, which includes tracking the edited status of Country objects, initiating object archival upon application termination, and setting up the application at launch time.

Defining the Classes of Travel Advisor

Travel Advisor has three classes: Country, Converter, and TAController. Only TAController has outlets and actions. And, rather than defining the Converter class, you are simply going to add it to the project from the CurrencyConverter project and reuse it.

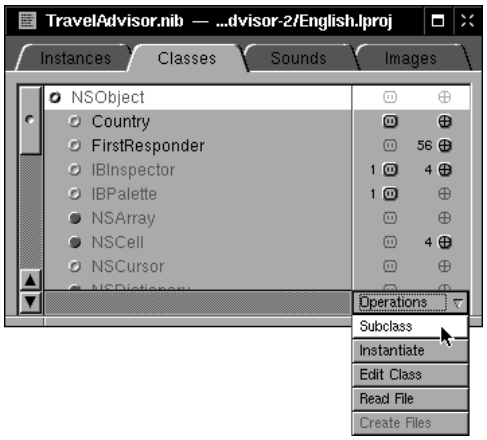
1 **Specify the Country and TAController classes.**

In Interface Builder, bring up the Classes display of the nib file window.

For each class, select NSObject as the superclass.

Choose Subclass from the Operations menu.

Type the class name.



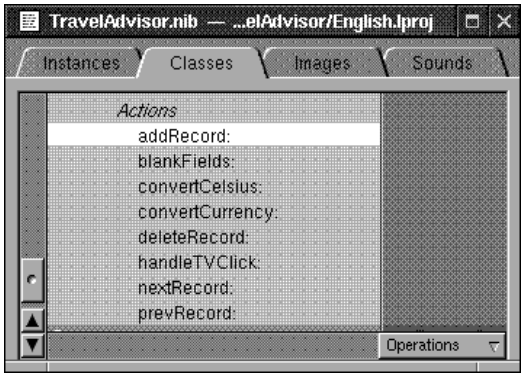
2 **Specify TAController's outlets.**

Add the outlets shown in the nib file window at right.

Through this outlet, the TAController object establishes a connection with the instance of the Converter class. You will reuse this class later in this section.

3 **Specify TAController's actions.**

Define the action methods shown in the nib file window at right.



In OpenStep there are many ways to reuse objects through their classes. For example, subclassing an existing class to obtain slightly different behavior is one way to reuse the functionality of the superclass. Another way is to integrate an existing class—like the Converter class—into your project.

4 **Reuse the Converter class.**

In Interface Builder:

Open **CurrencyConverter.nib** in the **English.lproj** subdirectory of the CurrencyConverter project directory.

In the Classes display of the nib file window, select the Converter class.

Choose Edit ► Copy.

Select the nib file window for **TravelAdvisor.nib**.

In the Classes display, select the superclass (NSObject).

Choose Edit ► Paste.

Make sure to select the superclass before pasting.

In Project Builder:

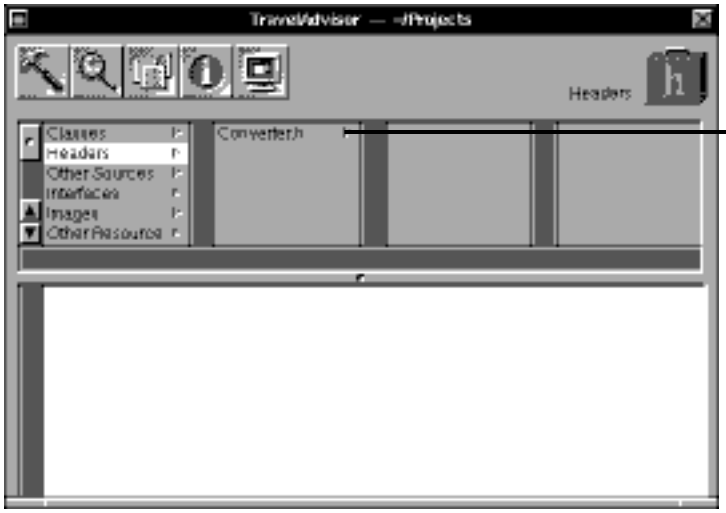
Launch Project Builder.

Select Classes in the project browser.

Choose Project ► Add Files.

In the Add Classes panel, navigate to the CurrencyConverter project directory and select **Converter.m**.

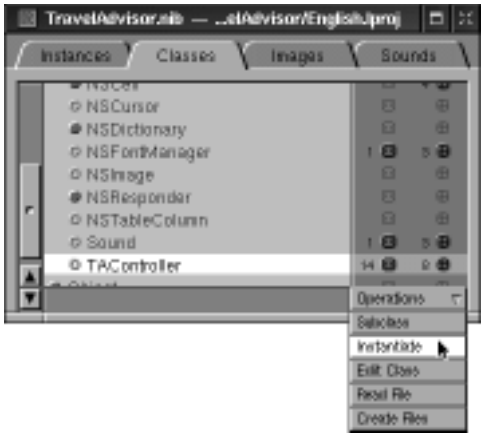
When asked if you want to include the header file, click OK.



When you add a class to a project, Project Builder adds the associated header file too.

It copies both files from the source location.

5 **Generate instances of the TAController and Converter classes.**



You don't need to instantiate the Country class in the nib file because it is not involved in any outlet or action connections. TAController interacts behind the scenes with users as they manipulate the application's interface. It therefore needs access to interface objects and to be made the target of action messages.

6 **Connect the TAController instance to its outlets.**

Outlet	Make Connection To
celsius	Text field labelled "Celsius"
commentsLabel	Label that reads "Notes and Itinerary for"
commentsField	Text object within scroll view
converter	Instance of Converter class (cube in Instances display)
countryField	Text field labelled "Country"
currencyDollarsField	Text field labelled "Dollars"
currencyLocalField	Text field labelled "Local"
currencyNameField	Text field labelled "Currency"
currencyRateField	Text field labelled "Rate"
englishSpokenSwitch	Switch (button) labelled "English widely spoken"
fahrenheit	Text field labelled "Fahrenheit"
languagesField	Text field labelled "Languages"
logisticsForm	Form in group (box) labelled "Logistics"; the form is selected when a gray line borders it.
tableView	The area underneath the "Countries" column

7 **Connect the TAController instance to the interface via its actions.**

Action	Make Connection From
addRecord:	"Add" button
blankFields:	"Clear" button
convertCelsius:	"Convert" button to the right of the "Fahrenheit" field
convertCurrency:	"Convert" button to the right of the "Local" field
deleteRecord:	"Delete" button
handleTVClick:	The table view(the area beneath the "Countries" column header)
nextRecord:	The "Next Record" menu command on the Records submenu
prevRecord:	The "Prior Record" menu command on the Records submenu
switchChecked:	The "English widely spoken" switch

You can assign delegates programmatically or by using Interface Builder. For more information, see "Getting in on the Action: Delegation and Notification" on page 97.

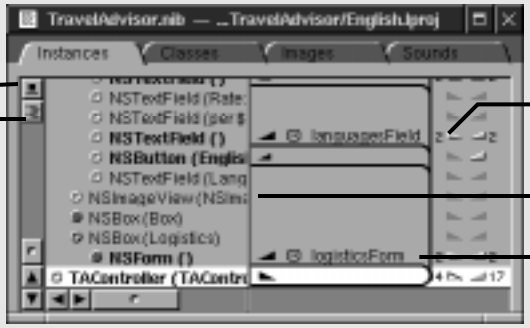
Before You Go On

You're next going to connect objects through an outlet defined by several OpenStep classes. The value of this outlet, named **delegate**, is the **id** of a custom object. As the delegate of NSApp (the NSApplication object), TAController will receive messages from it as certain events happen.

Checking Connections in Outline Mode

The nib file window of Interface Builder gives you two modes in which to view the objects in a nib file and to make connections between those objects. So far you've been working in the *icon mode* of the Instances display, which pictorially represents objects such as windows and custom objects.

Outline mode, as the phrase suggests, represents objects in a hierarchical list: an outline. The advantages of outline mode are that it represents all objects and graphically indicates the connections between them. You can connect objects through their outlets and actions in outline mode, as well as disconnect them by Control-clicking a connection line.



Click here for icon mode.

Click here for outline mode.

Connect objects in outline mode just as you do in icon mode: Control-drag a connection line between objects.

Click a right-pointing triangle to see connections out; click a left-pointing triangle to see connections into the object.

Move the vertical line left or right to see details (this is a vertical split view).

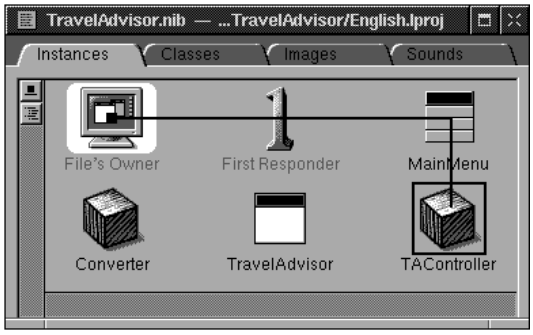
A connection is identified by name and icon for type (electrical outlet for outlet, cross-hairs for action)

Every application has a global NSApplication object (called NSApp) that coordinates events specific to the application. Among many other messages, NSApp sends a message to its delegate notifying it that the application is about to terminate. Later, you will implement TAController so that, when it receives this message, it archives (saves) the dictionary containing the Country objects.

8 **Connect the delegate outlet.**

Drag a connection line from File's Owner to the TAController object.

In the Connections display of the Inspector panel select **delegate** and click OK.



*Notice that the direction of the connection is **from** the File's Owner object (which is the application object) **to** the TAController object.*

9 **Generate source code files for the TAController and Country classes.**

When you generate the header and implementation files for all classes of Currency Converter, you are finished with the Interface Builder portion of development. Be sure you save the nib file before you switch over to Project Builder.

Save **TravelAdvisor.nib**.

Select the class in the Classes display of the nib file window.

Choose Create Files from the Operations pull-down menu.

File's Owner

Every nib file has one owner, represented by the File's Owner icon in a nib file window. The owner is an object, external to the nib file, that relays messages between the objects unarchived from the nib file and the other objects in your application.

You can specify a file's owner in Interface Builder or programmatically, with NSBundle's **loadNibNamed:owner:**. The File's Owner icon for the main nib file always represents NSApp, the global NSApplication constant. The main nib file is automatically created when you create an application project; it is loaded in **main()** when an application is launched.

Nib files other than the main nib file—*auxillary nib files*—contain objects and resources that an application may load only when it needs them (for example, an Info panel). You must specify the owner of auxillary nib files.

You can determine or set the class of the current nib file's owner in Interface Builder by selecting the File's Owner icon in the nib file window and then displaying the Custom Class inspector view. You'll get to practice this technique when you learn how to create multi-document applications in the next tutorial.

Just Add a Smock: Compiled and Dynamic Palettes

A palette is a display on the Palettes window that holds one or more reusable objects. You can add these objects to your application's interface using the drag-and-drop technique. There are two types of palettes: dynamic and compiled (also called "static palettes"). To the user, they seem identical, but the differences are many.

Static palettes are built as a project and have code defining their objects; dynamic palettes include no special code—they're unique configurations of objects found on static palettes. Consequently, static palettes must be compiled, but you can create dynamic palettes on the fly, without writing and compiling code. Objects on static palettes can have inspectors and editors, which dynamic-palette objects cannot.

You usually create a static palette as a way to distribute your objects—and the logic informing these objects' behavior—to potential users. Many developers of commercial OpenStep objects make use of static palettes as a distribution media. Creating static palettes (and their inspectors and editors) is a more complex process than creating dynamic palettes, but the resulting product has more value added to it.

Using Dynamic Palettes

Dynamic palettes are a big convenience. You can save groups of objects, with or without their interconnections, to a dynamic palette at any time. You can save dynamic palettes and store them in the file system, just as you do with the traditional compiled palette. You can remove the palette from the Palette viewer and, when you need it again, load it back into Interface Builder.

To store objects on a dynamic palette:

- Choose Tools ► Palettes ► New to create a blank palette.
- Select objects singly or in groups on the interface or in the nib file window (either icon or outline mode)
- Alternate-drag these objects and drop them on the blank palette.

Alternate-drag to move objects onto palettes, to move objects around palettes, and to remove objects from palettes.

You can use dynamic palettes to:

- Store collections of often-used View objects configured with specific sizes and other attributes. For instance, you could have a "standard" text field of a certain length, font, and background color stored on a dynamic palete.
- Hold windows and panels that are replicated in your projects (such as Info panels).
- Store versions of interfaces.
- Keep interconnected objects as a template that you can later use as-is or modify for particular circumstances. For instance, you could store a group of text fields and their delegate, or a set of controls and their connections to a controller object
- Assist in prototyping and group work. For example, you could mail a palette file containing an interface to interested parties.

Implementing the Country Class

Although it has no outlets, the Country class defines a number of instance variables that correspond to the fields of Travel Advisor.

1 **Declare instance variables.**

In Project Builder, click Headers in the project browser, then select **Country.h**.

Add the declarations shown between the braces at right.

```
@interface Country : NSObject <NSCoding>      /* 1 */
{
    NSString *name;                           /* 2 */
    NSString *airports;
    NSString *airlines;
    NSString *transportation;
    NSString *hotels;
    NSString *languages;
    BOOL     englishSpoken;
    NSString *currencyName;
    float    currencyRate;                    /* 3 */
    NSString *comments;
}
```

When a class adopts a protocol, it asserts that it implements the methods the protocol declares. Classes that archive or serialize their data must adopt the NSCoding protocol. See *Object-Oriented Programming and the Objective-C Language* for more on protocols.

1. Declares that the Country class adopts the NSCoding protocol
2. Explicitly types the instance variable as "a pointer to class NSString"—or a NSString object. See below for more about the NSString class.
3. Declare non-object instance variables the same way you declare them in C programs. In this case, **currencyRate** is of type **float**.

NSString: A String for All Countries

NSString objects represent character strings. They're behind almost all text in an application, from labels to spreadsheet entries to word-processing documents. NSStrings (or *string objects*) supplant that familiar C programming data type, **char ***.

"But why?" you might be saying. "Why not stick with the tried and true?" By representing strings as objects, you confer on them all the advantages that belong to objects, such as persistency and distributability. Moreover, thanks to data encapsulation, string objects can use whatever encoding is needed and can choose the most efficient storage for themselves.

The most important rationale for string objects is the role they play in *internationalization*. String objects contain Unicode characters rather than the narrow range of characters afforded by the ASCII character set. Hence they can represent words in Chinese, Japanese, Arabic,and many other languages.

The NSString and NSMutableString classes provide API to create static and dynamic strings, respectively, and to perform string operations such as substring searching, string comparison, and concatenation.

None of this prevents you from using **char *** strings, and there are occasions where for performance or other reasons you should. However, the public interfaces of OpenStep classes now use string objects almost exclusively. A number of NSString methods enable you to convert string objects to **char *** strings and back again.

Country.h also declares a dozen or more methods. Most of these are *accessor methods*. Accessor methods fetch and set the values of instance variables. They are a critical part of an object's interface.

2 **Declare methods.**

After the instance variables, add the declarations listed here.

```
/* initializtion and de-allocation */
- (id)init;                                /* 1 */
- (void)dealloc;
/* archiving and unarchiving */
- (void)encodeWithCoder:(NSCoder *)coder;   /* 2 */
- (id)initWithCoder:(NSCoder *)coder;
/* accessor methods */
- (NSString *)name;                        /* 3 */
- (void)setName:(NSString *)str;
- (NSString *)airports;
- (void)setAirports:(NSString *)str;
- (NSString *)airlines;
- (void)setAirlines:(NSString *)str;
/* ...other accessor method declarations follow... */
```

1. **Object initialization and deallocation.** In OpenStep you usually create an object by allocating it (**alloc**) and then initializing it (**init** or **init**... variant):

   ```
   Country *aCountry = [[Country alloc] init];
   ```

   When Country's **init** method is invoked, it initializes its instance variables to known values and completes other start-up tasks. Similarly, when an object is deallocated, its **dealloc** method is invoked, giving it the opportunity to release objects it's created, free **malloc**'d memory, and so on. You'll learn more about **init** and **dealloc** shortly.

2. **Object archiving and unarchiving.** The **encodeWithCoder:** declaration indicates that objects of this class are to be archived. Archiving encodes an object's class and state (typically instance variables) in a file that is often stored within the application wrapper (that is, the "hidden" application directory). Unarchiving, through **initWithCoder:**, reads the encoded class and state data and restores the object to its previous state. There's more on this topic in the following pages.

3. **Accessor methods.** The declaration for accessor methods that *return* values is, by convention, the name of the instance variable preceded by the type of the returned value in parentheses. Accessor methods that *set* the value of instance variables begin with "set" prepended to the name of the instance variable (initial letter capitalized). The "set" method's argument takes the type of the instance variable and the method itself returns void.

The Foundation Framework: Capabilities, Concepts, and Paradigms

The Foundation Framework consists of a base layer of classes that specify fundamental object behavior plus a number of utility classes. It also introduces several paradigms that define functionality not covered by the Objective-C language. Notably, the Foundation Framework:

- Makes software development easier by introducing consistent conventions for things such as object deallocation
- Supports Unicode strings, object persistence, and object distribution
- Provides a level of operating-system independence, enhancing application portability

Root Class

NSObject, the principal root class, provides the fundamental behavior and interface for objects. It includes methods for creating, initializing, deallocating, copying, comparing, and querying objects. Almost all OpenStep objects inherit ultimately from NSObject.

Deallocation of Objects

The Foundation Framework introduces a mechanism for ensuring that objects are properly deallocated when they're no longer needed. This mechanism, which depends on general conformance to a policy of object ownership, automatically tracks objects that are marked for release within a loop and deallocates them at the close of the loop. See "Object Ownership, Retention, and Disposal" on page 88 for more information.

Data Storage and Access

The Foundation Framework provides object-oriented storage for

- Arrays of raw bytes (NSData) and characters (NSString)
- Simple C data values (NSValue and NSNumber)
- Objective-C objects of any class (NSArray, NSDictionary, NSSet, and NSPPL)

NSArray, NSDictionary, and NSSet (and related mutable classes) are *collection classes* that also allow you to organize and access objects in certain ways (see "The Collection Classes" on page 74).

Text and Internationalization

NSString internally represents text in various encodings, most importantly Unicode, making applications inherently capable of expressing a variety of written languages. NSString also provides methods for searching, combining, and comparing strings. NSCharacterSet represents various groupings of characters which are used by NSString. An NSScanner object scans numbers and words from an NSString object. For more information, see "NSString: A String for All Countries" on page 82.

You use NSBundle objects to load code and localized resources dynamically (see "Only When Needed: Dynamically Loading Resources and Code" on page 118). The NSUserDefaults class enables you to store and access default values based on locale.

Object Persistence and Distribution

NSSerializer makes it possible to represent the data that an object contains in an architecture-dependent way. NSCoder and its subclasses take this process a step further by storing class information along with the data, thereby enabling archiving and distribution. Archiving (NSArchiver) stores encoded objects and other data in files. Distribution denotes the transmission of encoded object data between different processes and threads (NSPortCoder, NSConnection, NSDistantObject, and others).

Other Functionality

Date and time. The NSDate, NSCalendarDate, and NSTimeZone classes generate objects that represent dates and times. They offer methods for calculating temporal differences, for displaying dates and times in any desired format, and for adjusting times and dates based on location in the world.

Application coordination. NSNotification, NSNotificationCenter, and NSNotificationQueue implement a system for broadcasting notifications of changes within an application. Any object can specify and post a notification, and any other object can register itself as an observer of that notification. You can use an NSTimer object to send a message to another object at specific intervals.

Operating system services. Many Foundation classes help to insulate your code from the peculiarities of disparate operating systems.

- NSFileManager provides a consistent interface for file-system operations such as creating files and directories, enumerating directory contents, and moving, copying, and deleting files.
- NSThread and NSProcessInfo let you create multi-threaded applications and query the environment in which an application runs.
- NSUserDefaults allows applications to query, update, and manipulate a user's default settings across several domains: globally, per application, and per language.

Before You Go On

If you don't want to allow an instance variable's value to be changed by anyone outside of your class, *don't* provide a set method for the instance variable. If you do provide a set method, make sure objects of your own class use it when specifying a value for the instance variables. This has important implications for subclasses of your class.

Exercise: The previous example shows the declarations for only a few accessor methods. Every instance variable of the Country class should have an accessor method that returns a value and one that sets a value. Complete the remaining declarations.

Now that you've declared the Country class's accessor methods, implement them.

3 **Implement the accessor methods.**

Select **Country.m** in the project browser.

Write the code that obtains and sets the values of instance variables.

```
- (NSString *)name                          /* 1 */
{
    return name;
}

- (void)setName:(NSString *)str            /* 2 */
{
    [name autorelease];
    name = [str copy];
}

/* more accessor method implementations follow */
```

1. For "get" accessor methods (at least when the instance variables, like Travel Advisor's, hold immutable objects) simply return the instance variable.

2. For accessor methods that set *object* values, first send **autorelease** to the current instance variable, then **copy** (or **retain**) the passed-in value to the variable. The **autorelease** message causes the previously assigned object to be released at the end of the current event loop, keeping current references to the object valid until then.

   If the instance variable has a non-object value (such as an integer or float value), you don't need to **autorelease** and **copy**; just assign the new value.

In many situations you can send **retain** instead of **copy** to keep an object around. But for "value" type objects, such as Country's instance variables, **copy** is better. For the reason why, and for more on **autorelease**, **retain**, **copy**, and related messages for object disposal and object retention, see "Object Ownership, Retention, and Disposal" on page 88.

Before You Go On

Exercise: The example above shows the implementation of the accessor methods for the **name** instance variable. Implement the remaining accessor methods.

4 **Write the object-initialization and object-deallocation code.**

Implement the **init** method, as shown here.

Implement the **dealloc** method, following the suggestions in the Required Exercise, below.

```
- (id)init
{
    [super init];                /* 1 */

    name = @"";                  /* 2 */
    airports = @"";
    airlines = @"";
    transportation = @"";
    hotels = @"";
    languages = @"";
    currencyName = @"";
    comments = @"";

    return self;                 /* 3 */
}
```

1. Invokes **super**'s (the superclass's) **init** method to have inherited instance variables initialized. Always do this first in an **init** method.

Don't substitute **nil** when empty objects are expected, and vice versa.The Objective-C keyword **nil** represents an "object" with an **id** (value) of zero. An empty object (such as @"") is a true object; it just has no content of its given type. To learn more about Objective-C keywords, see *Object-Oriented Programming and the Objective-C Language*.

2. Initializes an NSString instance variable to an empty string. **@""** is a compiler-supported construction that creates an immutable NSString object from the text enclosed by the quotes. You could have just as well typed:

```
name = @"Howdy Doody";
```

   But that wouldn't have been practical as an initial value. You don't need to initialize instance variables to null values because the run-time system does it for you; it assigns **nil** to objects, zeroes to integers and floats, and **NULL** to **char ***'s if they're not explicitly initialized. However, you should initialize instance variables that take other starting values.

3. By returning **self** you're returning a true instance of your object; up until this point, the instance is considered undefined.

Before You Go On

Note that **release** itself doesn't deallocate objects, but it leads to their deallocation. For more on **release** and **autorelease**, see "Object Ownership, Retention, and Disposal" on page 88.

Implement the **dealloc** method. In this method you release (that is, send **release** or **autorelease** to) objects that you've created, copied, or retained (which don't have an impending **autorelease**). For the Country class, release all objects held as instance variables. If you had other retained objects, you would release them, and if you had dynamically allocated data, you would free it. When this method completes, the Country object is deallocated. The **dealloc** method should send **dealloc** to **super** as the *last* thing it does, so that the Country object isn't released by its superclass before it's had the chance to release all objects it owns.

You want the Country objects created by the Travel Advisor application to be *persistent*. That is, you want them to "remember" their state between sessions. Archiving lets you do this by encoding the state of application objects in a file along with their class membership. The NSCoding protocol defines two methods that enable archiving for a class: **encodeWithCoder:** and **initWithCoder:**.

5 **Implement the methods that archive and unarchive the object.**

Implement the **encodeWithCoder:** method, as shown at right.

```
- (void)encodeWithCoder:(NSCoder *)coder
{
    [coder encodeObject:name];                              /* 1 */
    [coder encodeObject:airports];
    [coder encodeObject:airlines];
    [coder encodeObject:transportation];
    [coder encodeObject:hotels];
    [coder encodeObject:languages];
    [coder encodeValueOfObjCType:"s" at:&englishSpoken]; /* 2 */
    [coder encodeObject:currencyName];
    [coder encodeValueOfObjCType:"f" at:&currencyRate];
    [coder encodeObject:comments];
}
```

1. The **encodeObject:** method encodes a single object in the archival file.

2. For both object and non-object types, you can use **encodeValueOfObjCType:at:**.

Implement the **initWithCoder:** method, as shown at right.

```
- (id)initWithCoder:(NSCoder *)coder
{
    name = [[coder decodeObject] copy];                 /* 1 */
    airports = [[coder decodeObject] copy];
    airlines = [[coder decodeObject] copy];
    transportation = [[coder decodeObject] copy];
    hotels = [[coder decodeObject] copy];
    languages = [[coder decodeObject] copy];
    [coder decodeValueOfObjCType:"s" at:&englishSpoken];
    currencyName = [[coder decodeObject] copy];
    [coder decodeValueOfObjCType:"f" at:&currencyRate];
    comments = [[coder decodeObject] copy];

    return self;                                        /* 2 */
 }
```

The NSCoder class provides a number of methods for encoding and decoding objects and data of standard C types. See the specification of the NSCoder class in the Foundation framework reference documentation.

1. The order of decoding should be the same as the order of encoding; since **name** is encoded first it should be decoded first. Use **copy** when you assign value-type objects to instance variables (see "Object Ownership, Retention, and Disposal" on page 88). NSCoder defines **decode...** methods that correspond the **encode...** methods, which you should use.

2. As in any **init...** method, end by returning **self**—an initialized instance.

Object Ownership, Retention, and Disposal

The problem of object ownership and disposal is a natural concern in object-oriented programming. When an object is created and passed around various "consumer' objects in an application, which object is responsible for disposing of it? And when? If the object is not deallocated, memory leaks. If the object is deallocated too soon, problems may occur in other objects that assume its existence, and the application may crash.

The Foundation Framework introduces a mechanism and a policy that helps to ensure that objects are deallocated when—and only when—they are no longer needed.

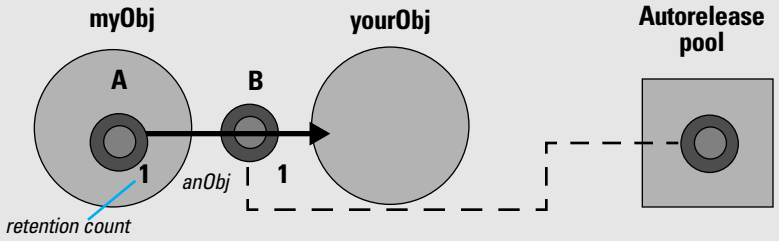
Who Owns Which Object?

The policy is quite simple: You are responsible for disposing of all objects that you own. You own objects that you create, either by allocating or copying them. You also own (or share ownership in) objects that you retain, since **retain** increments an object's reference count (see facing page). The flip side of this rule is: If you don't own an object, you need not worry about releasing it.

OK, but now another question arises. If the owner of an object *must* release the object within its programmatic scope, how can it give that object to other objects? The short answer is: the **autorelease** method, which marks the receiver for later release, enabling it to live beyond the scope of the owning object so that other objects can use it.

The **autorelease** method must be understood in a larger context of the *autorelease mechanism* for object deallocation. Through this programmatic mechanism, you implement the policy of object ownership and disposal.

How Autorelease Pools Work: An Example



A. **myObj** creates an object:

```
anObj = [[MyClass alloc] init];
```

B. **myObj** returns the object to **yourObj**, autoreleased:

```
return [anObj autorelease];
```

The object is "put" in the autorelease pool; that is, the autorelease pool starts tracking the object.

C. **yourObj** retains the object:

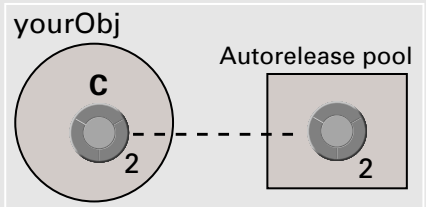
```
[anObj retain];
```

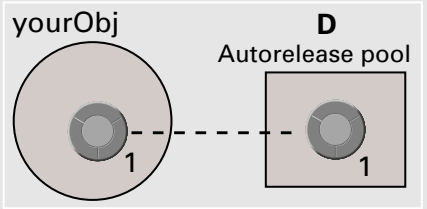
If the object wasn't retained it would be deallocated at the end of the current event cycle.

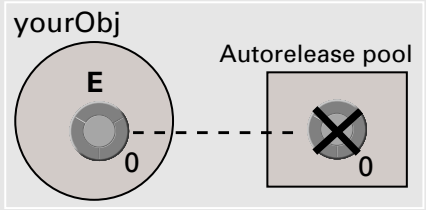
D. At the end of the event cycle, the autorelease pool sends **release** to all of its objects, thereby decrementing their reference counts. Now with a reference count of 1, **anObj** stays in the autorelease pool.

E. **yourObj** sends **autorelease** to the object. At the end of the event cycle, the autorelease pool sends **release** to its objects; since **anObj**'s reference count is now zero, it's deallocated.

For a fuller description of object ownership and disposal, see the introduction to the Foundation Framework reference documentation.







Reference Counts, Autorelease Pools, and Deallocation

Each object in the Foundation Framework has an associated reference count. When you allocate or copy an object, its reference count is set at 1. You send **release** to an object to decrement its reference count. When the reference count reaches zero, NSObject invokes the object's **dealloc** method, and the object is destroyed. However, successive consumers of the object can delay its destruction by sending it **retain**, which increments the reference count. You retain objects to ensure that they won't be deallocated until you're done with them.

Each application has an *autorelease pool*. An autorelease pool tracks objects marked for eventual release and releases them at the appropriate time. You put an object in the pool by sending the object an **autorelease** message. When your code finishes executing and control returns to the application object (typically at the end of the event cycle), the application object sends **release** to the autorelease pool, and the pool releases each object it contains. If afterwards the reference count of an object in the pool is zero, the object is deallocated.

Putting the Policy Into Practice

When an object is used solely within the scope of the method that creates it, you can deallocate it immediately by sending it **release**. Otherwise, send **autorelease** to all created objects that you no longer need but will return or pass to other objects.

You shouldn't release objects that you receive from other objects (unless you precede the **release** or **autorelease** with a **retain**). You don't own these objects, and can assume that their owner has seen to their eventual deallocation. You can also assume that (with some exceptions, described below) a received object remains valid within the method it was received in. That method can also safely return the object to its invoker.

You should send **release** or **autorelease** to an object only as many times as are allowed by its creation (one) plus the number of **retain** messages you have sent it. You should never send **free** to a OpenStep object.

Implications of Retained Objects

When you retain an object you're sharing it with its owner and other objects that have retained it. While this might be what you want, it can lead to some undesirable consequences. If the owner is released, any object you received from it and retained is usually invalid. If you had retained an instance variable of the owning object, and that instance variable is reassigned, your reference would also become invalid.

copy Versus retain

When deciding whether to retain or copy objects, it helps to categorize them as *value objects* or *entity objects*. Value objects are objects such as NSNumbers or NSStrings that encapsulate a discrete, limited set of data. Entity objects, such as NSViews and NSWindows, tend to be larger objects that manage and coordinate subordinate objects. For value objects, use **copy** when you want your own "snapshot" of the object; use **retain** when you intend to share it. Always retain entity objects.

In accessor methods that set value-object instance variables, you usually (but not always) want to make your own copy of the object and not share it. (Otherwise it might change without your knowing.) Send **autorelease** to the old object and then send **copy**—not **retain**—to the new one:

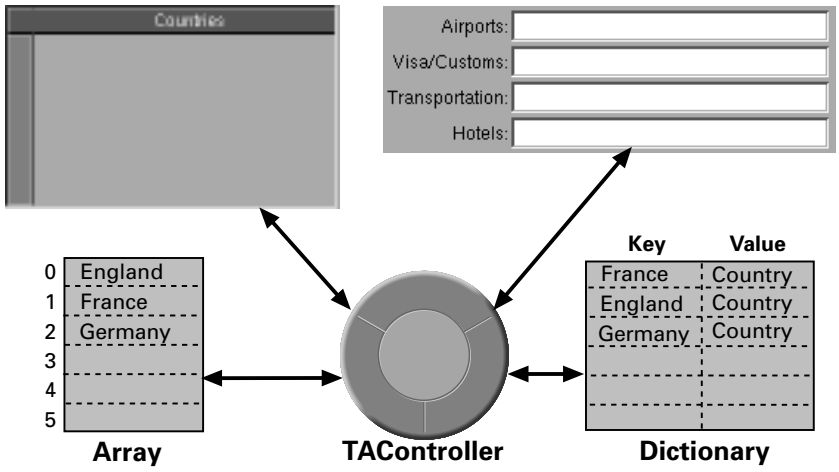
```
- (void)setTitle:(NSString *)newTitle
{
    [title autorelease];
    title = [newTitle copy];
}
```

OpenStep framework classes can, for reasons of efficiency, return objects cast as immutable when to the owner (the framework class) they are mutable. Thus there is no guarantee that a vended framework object won't change, even if it is of an immutable type. The precaution you should take is evident: copy objects obtained from framework classes if it's important the object shouldn't change from under you.

Implementing the TAController Class

The TAController class plays a central role in the Travel Advisor application. As the application's controller object, it transfers data from the model objects (Country instances) to the fields of the interface and, when users enter or modify data, back to the correct Country object. The TAController must also coordinate the data displayed in the table view with the current object, and it must do the right thing when users select an item in the table view or click the Add or Delete button. All custom code specific to the user interface resides in TAController.

The mechanics of this activity require an array (NSMutableArray) and a dictionary (NSMutableDictionary) for storing and accessing Country data. The following diagram illustrates the relationship among interface components, TAController, and the sources of data.



The dictionary contains Country objects (values) that are identified by the names of countries (keys). The dictionary is the source of data for the fields of Travel Advisor. The array derives from the dictionary and is sorted. It is the source of data for the table view.

After describing what other instance variables you must add to TAController, this section covers the following implementation tasks:

- Getting the data from Country objects to the interface and back
- Getting the table view to work, including updating Country records
- Adding and deleting "records" (Country objects)
- Formatting and validating field values
- "Housekeeping" tasks (application management)

1 **Update TAController.h.**

Import **Country.h**.

Add the instance-variable declarations shown at right.

```
    NSMutableDictionary *countryDict;
    NSMutableArray      *countryKeys;
    BOOL                recordNeedsSaving;
```

The variables **countryDict** and **countryKeys** identify the array and the dictionary discussed on the previous page. The boolean **recordNeedsSaving** flags that record if the user modifies the information in any field.

Add the **enum** declaration shown at right between the last **#import** directive and the **@interface** directive.

```
enum LogisticsFormTags {
    LGairports=0,
    LGairlines,
    LGtransportation,
    LGhotels
};
```

This declaration is not essential, but the **enum** constants provide a clear and convenient way to identify the cells in the Logistics form. Methods such as **cellAtIndex:** identify the editable cells in a form through zero-based indexing. This declaration gives each cell in the Logistics form a meaningful designation.

Turbo Coding With Project Builder

When you write code with Project Builder you have a set of "workbench" tools at your disposal, among them:

Indentation

In Preferences you can set the characters at which indentation automatically occurs, the number of spaces per indentation, and other global indentation characteristics. The Edit menu includes the Indentation submenu, which allows you to indent lines or blocks of code on a case-by-case basis.

Brace and Bracket Checking

Double-click a brace (left or right, it doesn't matter) to locate the matching brace; the code in-between the braces is highlighted. In an identical fashion, double-click a square bracket in a message expression to locate the matching bracket.

Name completion

Name completion is a facility that, given a partial name, completes it from all symbols known by the project. You activate it by pressing Escape (or Tab, if that key is bound in Preferences). You can use name completion in the code editor *and* in all panels where you are finding information or searching for files to open.

As an example: you know there's a certain constant to use with fonts, but you cannot remember it. In your code, type **NSFont**. Then press the Escape key several times. These symbols appear in succession (the found portion is underlined):

NSFontIdentityMatrix
NSFontManager
NSFontPanel

Emacs Bindings

You can issue the most common Emacs commands in Project Builder's code editor. (Emacs is a popular editor for writing code.) For example, there are the commands page-forward (Control-v), word-forward (Meta-f), delete-word (Meta-d), kill-forward (Control-k), and yank from kill ring (Control-y). You can also perform an incremental search by pressing Control-s; this command displays a small search panel and takes you to the next occurrence of whatever you type.

Data Mediation

TAController acts as the mediator of data exchanged between a source of data and the display of that data. Data mediation involves taking data from fields, storing it somewhere, and putting it back into the fields later. TAController has two methods related to data mediation: **populateFields:** puts Country instance data into the fields of Travel Advisor and **extractFields:** updates a Country object with the information in the fields.

2 **Implement the methods that transfer data to and from the application's fields.**

Implement the **populateFields:** method as shown at right.

```
- (void)populateFields:(Country *)aRec
{
    [countryField setStringValue:[aRec name]];         /* 1 */

    [[logisticsForm cellAtIndex:LGairports] setStringValue:
        [aRec airports]];                             /* 2 */
    [[logisticsForm cellAtIndex:LGairlines] setStringValue:
        [aRec airlines]];
    [[logisticsForm cellAtIndex:LGtransportation] setStringValue:
        [aRec transportation]];
    [[logisticsForm cellAtIndex:LGhotels] setStringValue:
        [aRec hotels]];

    [currencyNameField setStringValue:[aRec currencyName]];
    [currencyRateField setFloatValue:[aRec currencyRate]];
    [languagesField setStringValue:[aRec languages]];
    [englishSpokenSwitch setState:[aRec englishSpoken]];

    [commentsField setString:[aRec comments]];

    [countryField selectText:self];                   /* 3 */
}
```

1. Causes the Country field to display the value of the **name** instance variable of the Country record (**aRec**) passed into the method. Since **[aRec name]** is nested, the object it returns is used as the argument of **setStringValue:**, which sets the textual content of the receiver (in this case, an NSTextFieldCell).

2. The **cellAtIndex:** message is sent to the form and returns the cell identified by the **enum** constant LGairports.

3. Selects the text in the Country field or, if there is no text, inserts the cursor.

Although it doesn't do anything with data, the **blankFields:** method is similar in structure to **populateFields:**. The **blankFields:** method clears whatever appears in Travel Advisor's fields by inserting empty string objects and zeros.

Implement the **blankFields:** method as shown at right.

```
- (void)blankFields:(id)sender
{
    [countryField setStringValue:@""];

    [[logisticsForm cellAtIndex:LGairports] setStringValue:@""];
    [[logisticsForm cellAtIndex:LGairlines] setStringValue:@""];
    [[logisticsForm cellAtIndex:LGtransportation] setStringValue:@""];
    [[logisticsForm cellAtIndex:LGhotels] setStringValue:@""];

    [currencyNameField setStringValue:@""];
    [currencyRateField setFloatValue:0.000];
    [languagesField setStringValue:@""];
    [englishSpokenSwitch setState:NO];                /* 1 */

    [currencyDollarsField setFloatValue:0.00];
    [currencyLocalField setFloatValue:0.00];
    [celsius setIntValue:0];

    [commentsField setString:@"" ];                   /* 2 */
    [countryField selectText:self];
}
```

1. The **setState:** message affects the appearance of two-state toggled controls, such as a switch button. With an argument of YES, the checkmark appears; with an argument of NO, the checkmark is removed.

2. The **setString:** message sets the textual contents of NSText objects (such as the one enclosed by the scroll view).

Before You Go On

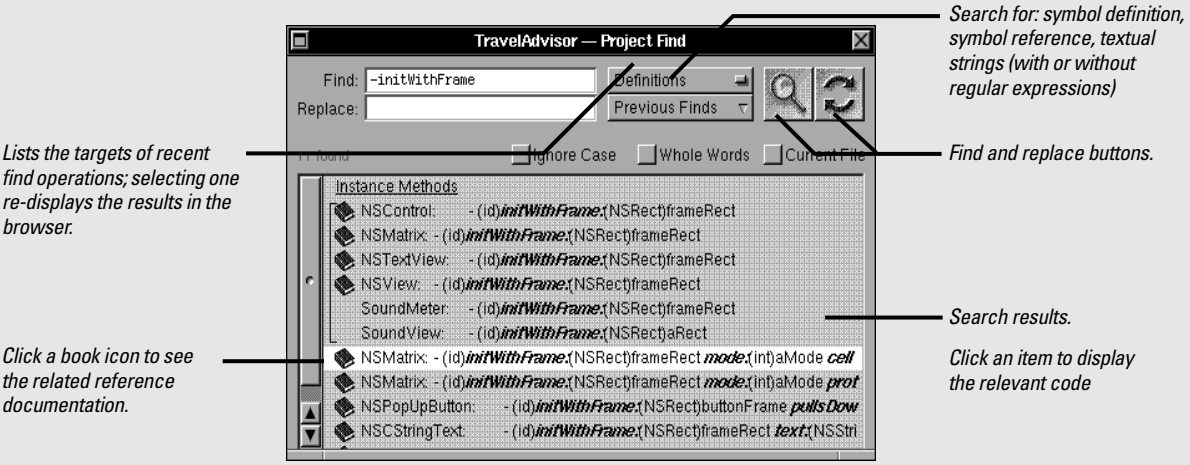
Exercise: Implement the **extractFields:** method. In this method set the values of the passed-in Country record's instance variables with the contents of the associated fields.

Tip: Use the **stringValue** method to get field contents and use Country's accessor methods to set the values of instance variables.

Finding Information Within Your Project

The Project Find Panel

The Project Find panel lets you find any symbol defined or referenced in your project. It also allows you to look up related reference documentation, search for text project-wide using regular expressions, and replace symbols or strings of text. To use the full power of Project Find, your project must be indexed; once it is, you have access to all symbols that the project references, including symbols defined in the frameworks and libraries linked into the project.



Symbol Definition Search Syntax

You can narrow your search for definitions of symbols by indicating type in the Find field of the Project Find panel along with the symbol name. Once the symbol items are listed in the browser, you can click an item to navigate to the definition in the header file, or click a book icon to display the relevant reference documentation.

The following table lists examples of searching for symbol definitions by type:

Example	Finds Definition For
@NSArray	NSArray class
<NSCoding>	NSCoding protocol
-objectAtIndex:	Instance method
+stringWithFormat:	Class method
[NSBox controlView]	Method specific to class
NSRunAlertPanel()	Function
NSApp	Type or constant

Other Ways of Finding Information

Project Builder includes other facilities for finding information:

- **Incremental search**:Control-s brings up the incremental-search panel for the currently edited file. As you type, the cursor advances to the next sequence of characters in the file that match what you type. Click Next (or press Control-s) to go to the next occurrence; click Prev (or press Control-r) to go to the previous occurrence.
- **Man pages**: Choose Edit ► Find ► Man Page to bring up the "Show man page" panel. Enter the name of a tool in the panel to get the man page on that tool.
- **Librarian via Services**: Select a symbol or any word (for example, "fonts") in Project Builder, then choose Services ► Librarian ► Search to have Digital Librarian find related documentation.
- **Help:** Project Builder and Interface Builder also feature context-sensitive help and task-related help. See "Where to Go For Help" in chapter 2, "Currency Converter Tutorial" for details.

Getting the Table View to Work

Table views are objects that display data as records (rows) with attributes (columns). The table view in Travel Advisor displays the simplest kind of record, with each record having only one attribute: a country name.

Table views get the data they display from a *data source*. A data source is an object that implements the informal NSTableDataSource protocol to respond to NSTableView requests for data. Since the NSTableView organizes records by zero-based indexing, it is essential that the data source organizes the data it provides to the NSTableView similarly: in an array.

3 **Implement the behavior of the table view's data source.**

In TAController's **awakeFromNib** method, create and sort the array of country names.

In the same method, designate **self** as the data source.

```
- (void)awakeFromNib
{
    NSArray *tmpArray = [[countryDict allKeys]         /* 1 */
        sortedArrayUsingSelector:@selector(compare:)];
    countryKeys = [[NSMutableArray alloc] initWithArray:tmpArray];

    [tableView setDataSource:self];                    /* 2 */
    [[[tableView tableColumns] objectAtIndex:0]        /* 3 */
        setIdentifier:@"Countries"];
    [tableView sizeLastColumnToFit];
}
```

1. The **[countryDict allKeys]** message returns an array of keys (country names) from the unarchived dictionary that contains Country objects as values. The **sortedArrayUsingSelector:** message sorts the items in this "raw" array using the **compare:** method defined by the class of the objects in the array, in this case NSString (this is an example of polymorphism and dynamic binding). The sorted names go into a temporary NSArray—since that is the type of the returned value—and this temporary array is used to create a mutable array, which is then assigned to **countryKeys**. A mutable array is necessary because users may add or delete countries from the application.

2. The **[tableView setDataSource:self]** message identifies the TAController object as the table view's data source. The table view will commence sending NSTableDataSource messages to TAController. (You can effect the same thing by setting the NSTableView's **dataSource** outlet in Interface Builder.)

3. Every column has an *identifier* to associate it with a column, which is itself usually associated with an attribute. By default, the identifier is a number: the first column is 0, the second column is 1, and so on. This compound message makes the identifier a string object and thus binds it semantically to the attribute. The **tableColumns** method returns all NSTableColumns in a array; in this case, only the single column of this table view. The **setIdentifier:** message sets the value.

If users are supposed to edit the cells of the table view, you would also make TAController the delegate of the table view at this point (with **setDelegate:**).The delegate receives messages relating to the editing and validation of cell contents. For details, see the specification on NSTableView in the Application Kit reference documentation.

To fulfill its role as data source, TAController must implement two methods of the NSTableDataSource informal protocol.

Implement two methods of the NSTableDataSource informal protocol:

- **numberOfRowsInTableView:**
- **tableView: objectValueForTableColumn: row:**

```
- (int)numberOfRowsInTableView:(NSTableView *)theTableView
{                                                       /* 1 */
    return [countryKeys count];
}

- (id)tableView:(NSTableView *)theTableView             /* 2 */
      objectValueForTableColumn:(NSTableColumn *)theColumn
            row:(int)rowIndex
{
    if ([[theColumn identifier] isEqualToString:@"Countries"])
        return [countryKeys objectAtIndex:rowIndex];
    else
        return nil;
}
```

1. Returns the number of country names in the **countryKeys** array.

   If you had an application with multiple table views, each would invoke this NSTableView delegation method (as well as the others). By evaluating the **theTableView** argument, you could distinguish which table view was involved.

2. This method first evaluates the column identifier to determine if it's the right column (it *should* always return "Countries"). If it is, the method returns the country name from the **countryKeys** array that is associated with **rowIndex**. This name is then displayed at **rowIndex** of the column. (Remember, the array and the cells of the column are synchronized in terms of their indexing.)

The NSTableDataSource informal protocol has a another method, **tableView:setObjectValue:forTableColumn:row:**, that you won't implement in this tutorial. This method allows the data source to extract data entered by users into table-view cells; since Travel Advisor's table view is read-only, there is no need to implement it.

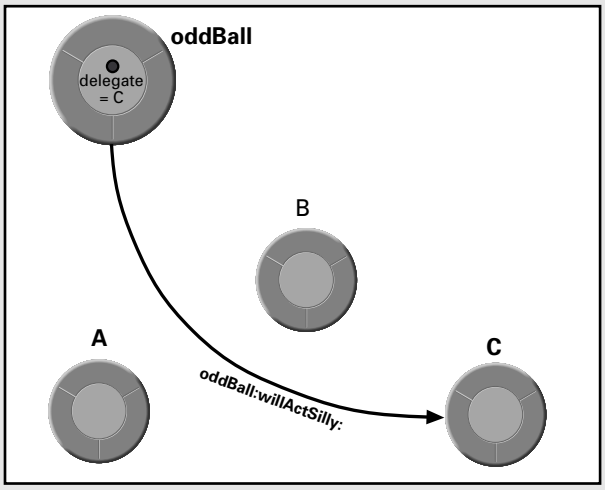
Getting in on the Action: Delegation and Notification

A lot goes on in a running application: events are being interpreted, files are being read, views are being drawn. Because your custom objects might be interested in any of these activities, OpenStep offer two mechanisms through which your objects can participate or be kept informed of events going on in the application: delegation and notification.

Delegation

Many OpenStep framework objects hold a *delegate* as an instance variable. A delegate is a object that receives messages from the framework object when specific events occur. Delegation messages are of several types, depending on the expected role of the delegate:

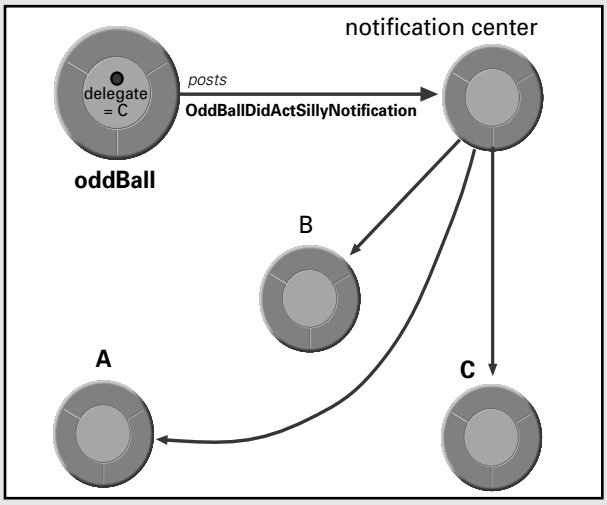
- Some messages are purely informational, occurring after an event has happened. They allow a delegate to coordinate its actions with the other object.
- Some messages are sent before an action will occur, allowing the delegate to veto or permit the action.
- Other delegation messages assign a specific task to a delegate, like filling a browser with cells.



You can set your custom object to be the delegate of a framework object programmatically or in Interface Builder. Your custom classes can also define their own delegate variables and delegation protocols for client objects.

Notification

A notification is a message that is broadcast to all objects in an application that are interested in the event the notification represents. As does the informational delegation message, the notification informs these *observers* that this event took place. It can also pass along relevant data about the event.



Here's the way the notification process works:

- Objects who are interested in an event that happens elsewhere in the application — say the addition of a record to a database — register themselves with a *notification center* (an instance of NSNotificationCenter) as observers of that event. Delegates of an object that posts notifications are automatically registered as observers of those notifications.
- The object that adds the object to the database (or some such event) *posts* a notification (an instance of NSNotification) to a notification center. The notification contains a tag identifying the notification, the **id** of the associated object, and, optionally, a dictionary of supplemental data.
- The notification center then sends a message to each observer, invoking the method specified by each, and passing in the notification.

Notifications hold some advantages over delegation messages as a means of inter-application communication. They allow an object to synchronize its behavior and state with *multiple* objects in an application, and without having to know the identity of those objects. With *notification queues*, it is also possible to post notifications asynchronously and coalesce similar notifications.

The final thing you need to do to get the table view working is to respond to mouse clicks in it. As you recall, you defined in Interface Builder the **handleTVClick:** action for this purpose. This method must do a number of things:

- Save the current Country object or create a new one.
- If there's a new record, re-sort the array providing data to the table view.
- Display the selected record.

4 **Update records.**

Implement the method that responds to user selections in the table view.

```
- (void)handleTVClick:(id)sender
{
    Country *aRec, *newRec, *newerRec;
    int index;

    /* does current obj need to be saved? */
    if (recordNeedsSaving) {                                /* 1 */
       /* is current object already in dictionary? */
      if (aRec=[countryDict objectForKey:[countryField stringValue]])
{
           /* remove if it's been changed */
           if (aRec) {
               NSString *country = [aRec name];
               [countryDict removeObjectForKey:country];
               [countryKeys removeObject:country];
           }
        }
        /* Create Country obj, add to dict, add name to keys array */
        newRec = [[Country alloc] init];
        [self extractFields:newRec];
        [countryDictsetObject:newRecforKey:[countryFieldstringValue]];
        [countryKeys addObject:[countryField stringValue]];

        /* sort array here */
        [countryKeys sortUsingSelector:@selector(compare:)];
        [tableView tile];
    }
    index = [sender selectedRow];
    if (index >= 0 && index < [countryKeys count]) {        /* 2 */
        newerRec = [countryDict objectForKey:
            [countryKeys objectAtIndex:index]];
        [self populateFields:newerRec];
        [commentsLabel setStringValue:[NSString stringWithFormat:
          @"Notes and Itinerary for %@", [countryField stringValue]]];
        recordNeedsSaving=NO;
    }
}
```

This method has two major sections, each introduced by an **if** statement.

1. When any Country-object data is added or altered, Travel Advisor sets the **recordNeedsSaving** flag to YES (you'll learn how to do this on later on). If **recordNeedsSaving** is YES, first delete any existing Country record for that country from the dictionary and also remove the country name from the table view's array. (Upon removal, the objects are automatically released by the array.) Then create a new Country instance and initialize it with the values currently on the screen; add the instance to the dictionary, add the country name to the table view's array, sort the array, and reset the **recordNeedsSaving** flag. At the end, invoke the **tile** method , which (among other things) causes the table view to request data from its data source.

2. The **selectedRow** message queries the table view for the row index of the cell that was clicked. If this index is within expected bounds, use it to get the country name from the array, and then use the country name as the key to get the associated Country instance. Write the instance-variable values of this instance to the fields of the application, update the "Notes and Itinerary for" label.

Optional Exercise

Application developers often like to have key alternatives to mouse actions such as clicking a table view. One way of acquiring a key alternative is to add a menu cell in Interface Builder, specify a key as an attribute of the cell, define an action method that will be invoked, and then implement that method.

The methods **nextRecord:** and **prevRecord:** should be invoked when users chose Next Record and Prev Record or type the key equivalents Command-n and Command-r. In **TAController.m**, implement these methods, keeping the following hints in mind:

1. Get the index of the selected row (**selectedRow**).

2. Increment or decrement this index, according to which key is pressed (or which command is clicked).

3. If the start or end of the table view is encountered, "wrap" the selection. (Hint: Use the index of the last object in the **countryKeys** array.)

4. Using the index, select the new row, but don't extend the selection.

5. Simulate a mouse click on the new row by sending **handleTVClick:** to **self**.

Adding and Deleting Records

When users click Add Record to enter a Country "record," the **addRecord:** method is invoked. You want this method to do a few things besides adding a Country object to the application's dictionary:

- Ensure that a country name has been entered.
- Make the table view reflect the new record.
- If the record already exists, update it (but only if it's been modified).

5 **Implement the method that adds a Country object to the NSDictionary "database."**

```
- (void)addRecord:(id)sender
{
    Country *aCountry;
    NSString *countryName = [countryField stringValue];
/* 1 */
   if (countryName && (![countryName isEqualToString:@""])) {
        aCountry = [countryDict objectForKey:countryName];
        if (aCountry && recordNeedsSaving) {
           /* remove old Country object from dictionary */
           [countryDict removeObjectForKey:countryName];
           [countryKeys removeObject:countryName];
           aCountry = nil;
         }
        if (!aCountry)  /* record is new or has been removed */
            aCountry = [[Country alloc] init];
        else /* record already exists and hasn't changed */
            return;
/* 2 */
        [self extractFields:aCountry];
        [countryDict setObject:aCountry forKey:[aCountry name]];
        [countryKeys addObject:[aCountry name]];
        [countryKeys sortUsingSelector:@selector(compare:)];
/* 3 */
        recordNeedsSaving=NO;
        [commentsLabel setStringValue:[NSString stringWithFormat:
           @"Notes and Itinerary for %@",[countryField stringValue]]
        [countryField selectText:self];
/* 4 */
        [tableView tile];
        [tableView selectRow:[countryKeys indexOfObject:
            [aCountry name]] byExtendingSelection:NO];
    }
}
```

1. This section of code verifies that a country name has been entered and sees if there is a Country object in the dictionary. If there's no object for the key, **objectForKey:** returns **nil**. If the object exists and it's flagged as modified, the code removes it from the dictionary and removes the country name from the

countryKeys array. Note that removing an object from a dictionary or array also releases it, so the code sets **aCountry** to **nil**. It then tests **aCountry** and, if it's **nil**, creates a new object; otherwise it just returns, because an object already exists for this country and it hasn't been modified.

2. After updating the new Country object with the information on the application's fields (**extractFields:**), this code adds the Country object to the dictionary and the country name to the **countryKeys** array.

3. This section of code performs some things that have to be done, such as resetting the **recordNeedsSaving** flag and updating the label over the scroll view to reflect the just-added country.

4. The **tile** message forces the table view to update its contents. The **selectRow:byExtendingSelection:** message highlights the new record in the table view.

Before You Go On

Exercise: Implement the **deleteRecord:** method. Although similar in structure to **addRecord:** this method is much simpler, because you don't need to worry about whether a Country record has been modified. Once you've deleted the record, remember to update the table view and clear the fields of the application.

Abstract Classes and Class Clusters

Many of the classes in the Foundation Framework fall into functional constellations of public and private classes called *class clusters*. Class clusters simplify the programming interface and permit more efficient storage of data.

An abstract class (such as NSArray) defines the public interface for objects vended from class clusters. Abstract classes declare methods common to private, concrete subclasses, but do not declare any instance variables to hold data—that's done by the private classes. When you send an object-creation message to an abstract class, it instantiates and returns an instance of the appropriate private subclass. What's appropriate depends on the creation method, which indicates the type of storage required. The class membership of the returned object is hidden, but its interface, as declared by the abstract superclass, is public.

Many OpenStep class clusters have two or more abstract classes. Usually one class provides the interface for obtaining immutable objects (for example, NSArray) and another class, which inherits from the mutable class, vends mutable versions of the same type of object (NSMutableArray).

Field Formatting and Validation

Travel Advisor has several numeric fields. Some display temperatures while others display currency amounts. In this stage, you'll enable these fields to format their contents by using a formatting API defined in the Application Kit.

6 **Format and validate numeric fields.**

Set the entry type and floating-point format of some TAController fields in the **awakeFromNib** method.

```
- (void)awakeFromNib
{
    [[currencyRateField cell] setEntryType:NSFloatType];
    [[currencyRateField cell] setFloatingPointFormat:YES
        left:2 right:1];
    [[currencyDollarsField cell] setEntryType:NSFloatType];
    [[currencyDollarsField cell] setFloatingPointFormat:YES left:5
        right:2];
    [[currencyLocalField cell] setEntryType:NSFloatType];
    [[currencyLocalField cell] setFloatingPointFormat:YES left:5
        right:2];
    [[celsius cell] setEntryType:NSFloatType];
    [[celsius cell] setFloatingPointFormat:YES left:2 right:1];
}
```

The NSCell class provides methods for specifying how cell values are formatted. In this instance, **setEntryType:** sets the type of value as a **float** and **setFloatingPointFormat:left:right:** specifies the number of digits on each side of the decimal point.

The NSControl class gives you an API for validating the contents of cells. Validation verifies that the values of cells fall within certain limits or meet certain criteria. In Travel Advisor, we want to make sure that the user does not enter a negative value in the Rate field.

The request for validation is a message—**control:isValidObject:**—that a control sends to its delegate. The control, in this case, is the Rate field.

In **awakeFromNib**, make TAController a delegate of the field to be validated.

```
    [currencyRateField setDelegate:self];
```

Implement the **control:isValidObject:** method to validate the value of the field.

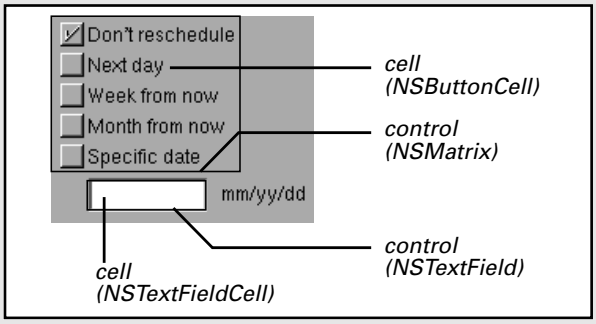
```
- (BOOL)control:(NSControl *)control isValidObject:(id)obj
{
    if (control == currencyRateField) {            /* 1 */
        if ([obj floatValue] < 0.0) {
           NSRunAlertPanel(@"Travel Advisor",      /* 2 */
             @"Rate cannot be negative.", nil, nil, nil);
            return NO;
        }
    }
    return YES;
}
```

Behind "Click Here": Controls, Cells, and Formatters

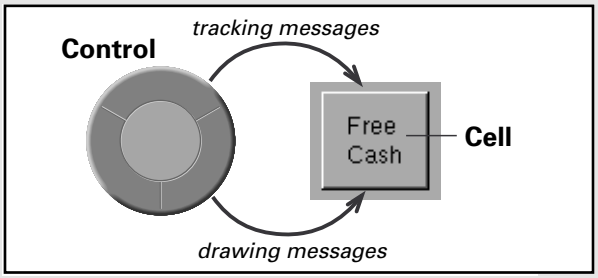
Controls and cells lie behind the appearance and behavior of most user-interface objects in OpenStep, including buttons, text fields, sliders, and browsers. Although they are quite different types of objects—controls inherit from NSControl while cells inherit from NSCell—they interact closely.

Controls enable users to signal their intentions to an application, and thus to *control* what is happening. By interpreting mouse and keyboard events and asking another object to respond to them, controls implement the target/action paradigm described in "Paths for Object Communication: Outlets, Targets, and Actions" on page 38. Controls themselves can hold targets and actions as instance variables, but usually they get this data from the affected cell (which must inherit from NSActionCell).

Cells are rectangular areas "embedded" within a control. A control can hold multiple cells as a way to partition its surface into active areas. Cells can draw their own contents either as text or image (and sometimes as both), and they can respond individually to user actions. Since cells are typically more frugal consumers of memory than controls, they help applications be more efficient.



Controls act as managers of their cells, telling them when and where to draw, and notifying them when a user event (mouse clicks, keystrokes) occurs in their areas. This division of labor, given the relative "weight" of cells and controls, provides a great boost to application performance.

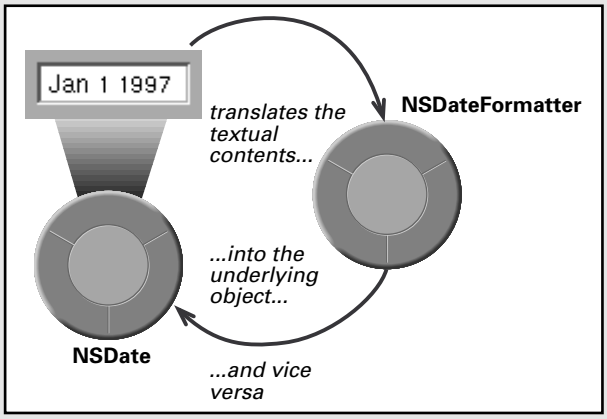


A control does not have to have a cell associated with it, but most user-interface objects available on Interface Builder's standard palettes are cell-control combinations. Even a simple button—from Interface Builder or programmatically created—is a control (an NSButton instance) associated with an NSButtonCell. The cells in a control such as a matrix must be the same size, but they can be of different classes. More complex controls, such as table views and browsers, can incorporate various types of cells.

Cells and Formatters

When one thinks of the contents of cells, it's natural to consider only text (NSString) and images (NSImage). The content seems to be whatever is displayed. However, cells can hold other kinds of objects, such as dates (NSDate), numbers (NSNumber), and custom objects (say, phone-number objects).

Formatter objects handle the textual representation of the objects associated with cells and translate what is typed into a cell into the underlying object. Using NSCell's **setFormatter:**, you must programmatically associate a formatter with a cell to get this behavior.

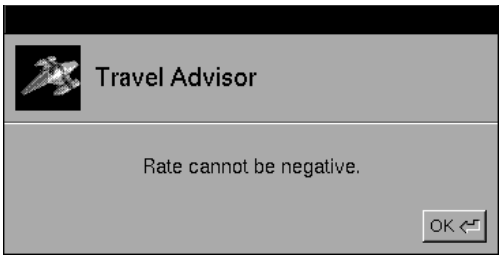


The Foundation Framework provides the NSDateFormatter class to generate date formatters and will release other specialized formatter classes in the future. You can make a custom subclass of NSFormatter to derive your own formatters.

1. Because you might have more than one field's value to validate, this example first determines which field is sending the message. It then checks the field's value (passed in as the second object); if it is negative, it displays an attention panel and returns NO, blocking the entry of the value. Otherwise, it returns YES and the field accepts the value.

For more information on **NSRunAlertPanel()**, see the "Functions" section of the Application Kit (framework) reference documentation.

2. The **NSRunAlertPanel()** function allows you to display a modal attention panel from any point in your code. The above example calls this function simply to inform the user why the value cannot be accepted.



Although Travel Advisor doesn't evaluate it, the **NSRunAlertPanel()** function returns a constant indicating which button the user clicks on the panel. The logic of your code could therefore branch according to user input. In addition, the function allows you to insert variable information (using **printf()**-style conversion specifiers) into the body of the message.

Application Management

By now you've finished the major coding tasks for Travel Advisor. All that remains to implement are a half dozen or so methods. Some of these methods perform tasks that every application should do. Others provide bits of functionality that Travel Advisor requires. In this section you'll:

- Archive and unarchive the TAController object.
- Implement TAController's **init** and **dealloc** methods.
- Save data when the application terminates.
- Mark the current record when users make a change.
- Obtain and display converted currency values.

The data that users enter into Travel Advisor should be saved in the file system, or *archived*. The best time to initiate archiving in Travel Advisor is when the application is about to terminate. Earlier you made TAController the delegate of the application object (NSApp). Now respond to the delegate message **applicationShouldTerminate:**, which is sent just before the application terminates.

7 **Archive the application's objects when it terminates.**

Implement the delegate method **applicationShouldTerminate:**, as shown at right.

```
- (BOOL)applicationShouldTerminate:(id)sender
{                                                          /* 1 */
   NSString *storePath = [[[NSBundle mainBundle] bundlePath]
        stringByAppendingPathComponent:@"TravelData"];
   /* save current record if it is new or changed */
   [self addRecord:self];
                                                           /* 2 */
   if (countryDict && [countryDict count])
        [NSArchiver archiveRootObject:countryDict toFile:storePath];

   return YES;
}
```

1. Constructs a pathname to the application wrapper in which to store the archive file "TravelData." The application wrapper—the "hidden" directory holding the application executable and required resources—is a bundle, so NSBundle methods are used to get the bundle path.

2. If the **countryDict** dictionary holds Country objects, TAController archives it with the NSArchiver class method **archiveRootObject:toFile:**. Since the dictionary is designated as the root object for archiving, all objects that the dictionary references (that is, the Country objects it contains) will be archived too.

8 **Implement TAController's methods for initializing and deallocating itself.**

Implement the **init** method, as shown at right.

Implement the **dealloc** method to release object instance variables.

```
- (id)init
{
/* 1 */
    NSString *storePath = [[NSBundle mainBundle]
        pathForResource:@"TravelData" ofType:nil];
    [super init];
/* 2 */
    countryDict = [NSUnarchiver unarchiveObjectWithFile:storePath];
/* 3 */
    if (!countryDict) {
        countryDict = [[NSMutableDictionary alloc] init];
        countryKeys = [[NSMutableArray alloc] initWithCapacity:10];
    } else
        countryDict = [countryDict retain];
    recordNeedsSaving=NO;

    return self;
}
```

1. Using NSBundle methods, locates the archive file "TravelData" in the application wrapper and returns the path to it.

2. The **unarchiveObjectWithFile:** message *unarchives* (that is, restores) the object whose attributes are encoded in the specified file. The object that is unarchived and returned is the NSDictionary of Country objects (**countryDict**).

3. If no NSDictionary is unarchived, the **countryDict** instance variable remains **nil**. If this is the case, TAController creates an empty **countryDict** dictionary and an empty **countryKeys** array. Otherwise, it retains the instance variable.

Flattening the Object Network: Coding and Archiving

Coding, as implemented by NSCoder, takes a network of objects such as exist in an application and serializes that data, capturing the state, structure, relationships, and class memberships of the objects. As a subclass of NSCoder, NSArchiver extends this behavior by storing the serialized data in a file.

When you archive a root object, you archive not only that object but all other objects the root object references, all objects those second-level objects reference, and so on. To be archived, however, objects must conform to the NSCoding protocol. This conformance requires that they implement the **encodeWithCoder:** and **initWithCoder:** methods.

Thus sending **archiveRootObject:toFile:** to NSArchiver leads to the invocation of **encodeWithCoder:** in the root object and in all referenced objects that implement it. Similarly, sending **unarchiveObjectWithFile:** to NSUnarchiver results in **initWithCoder:** being invoked in those objects referenced in the archive file. These objects reconstitute themselves from the instance data in the file. In this way, the network of objects, three-dimensional in abstraction, is converted to a two-dimensional stream of data and back again.

When users modify data in fields of Travel Advisor, you want to mark the current record as modified so later you'll know to save it. The Application Kit broadcasts a notification whenever text in the application is altered. To receive this notification, add TAController to the list of the notification's observers.

9 **Write the code that marks records as modified.**

In the **awakeFromNib** method, make TAController an observer of NSControlTextDidChangeNotification.

Implement **textDidChange:** to set the **recordNeedsSaving** flag.

```
    [[NSNotificationCenter defaultCenter] addObserver:self
         selector:@selector(textDidChange:)
         name:NSControlTextDidChangeNotification object:nil];
```

Next, implement the method that you indicated would respond to the notification; this method sets a flag, thereby marking the record as changed.

```
- (void)textDidChange:(NSNotification *)notification
{
    if ([notification object] == currencyDollarsField ||
        [notification object] == celsius) return;

    recordNeedsSaving=YES;
}
```

You post notifications and add objects as observers of notifications with methods defined in the NSNotificationCenter class. NSNotification defines methods for creating notification objects and for accessing their attributes. See the specifications of these classes in the Foundation Framework reference documentation.

Two of the editable fields of Travel Advisor hold temporary values used in conversions and so are not saved. This statement checks if these fields are the ones originating the notification and, if they are, returns without setting the flag. (The **object** message obtains the object associated with the notification.)

The final method to implement is almost identical to the one you wrote for Currency Converter to display the results of a currency conversion when the user clicks the Convert button for currency conversion.

10 **Implement the method that responds to a request for a currency conversion.**

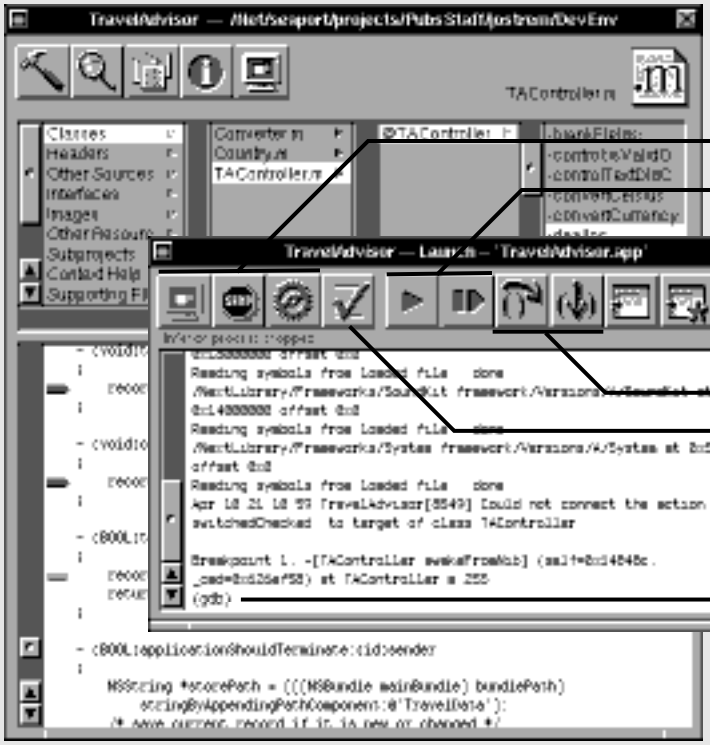
```
- (void)convertCurrency:(id)sender
{
    [currencyLocalField setFloatValue:
        [converter convertAmount:[currencyDollarsField floatValue]
        byRate:[currencyRateField floatValue]]];
}
```

Optional Exercise

Convert Celsius to Fahrenheit: Implement the **convertCelsius:** method. You've already specified and connected the necessary outlets (**celsius**, **fahrenheit**) and action (**convertCelsius:**), so all that remains is the method implementation. The formula you'll need is:

$F° = 9/5C° + 32$

Using the Graphical Debugger



Project Builder's graphical debugger provides an easy-to-use, intuitive user interface to **gdb**, the GNU debugger.

Launch program; run debugger; inspect task (breakpoints, stack, etc.)

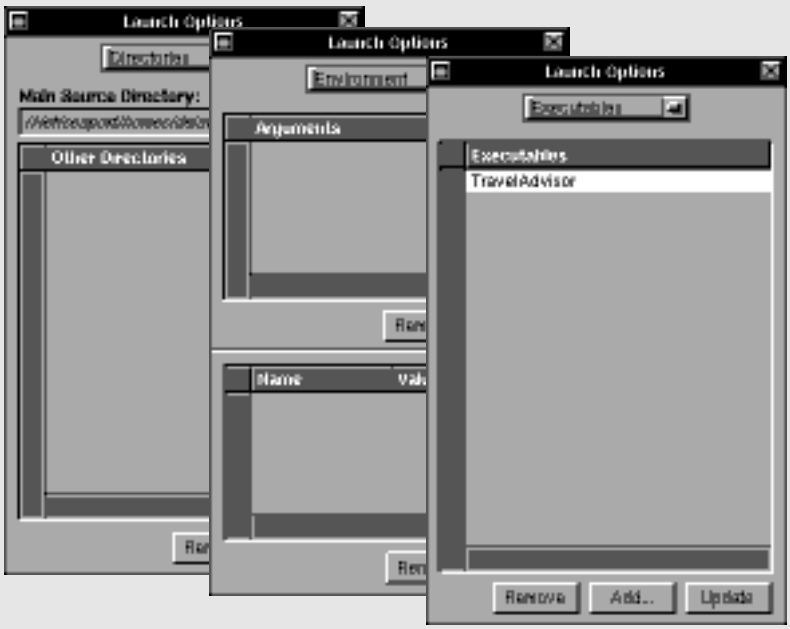
Run the application being debugged; interrupt and continue the application.

Print value, print referenced value, print object description (select variable first).

Step over, step into statement.

Launch options (see below)

You can also issue gdb commands on the command line.



Launch options affect both launched and debugged programs. The inspector displays allow you to set target executables, environment variables, and source directories.

Building and Running Travel Advisor

When Travel Advisor is built, start it up by double-clicking the icon in the File Manager. Then put the application through the following tests:

- Enter a few records. Make up geographical information if you have to—you're not trusting your future travels to this application. Not yet, anyway.
- Click the items in the table view and notice how the selected records are displayed. Press Command-n and Command-r and observe what happens.
- Enter values in the conversion fields to see how they're automatically formatted. Try to enter a negative value in the Rate field.
- Quit the application and then start it up again. Notice how the application displays the same records that you entered.

Tips for Eliminating Deallocation Bugs

Problems in object deallocation are not unusual in OpenStep applications under development. You might release an object too many times or you might not release an object as many times as is needed to deallocate it. Both situations lead to nasty problems—in the first case, to run-time errors when your code references non-existent objects; the second case leads to memory leaks.

If you're releasing an object too many times, you'll get run-time error messages telling you that a message was sent to a freed object. To find which methods were releasing the object, in **gdb** or the graphical debugger::

1 Send **enableFreedObjectCheck:** to NSAutoreleasePool with an argument of YES.

2 Set a breakpoint on **_NSAutoreleaseFreedObject**.

3 Run the program under the debugger.

4 When the program hits the breakpoint, do a backtrace and check the stack to find the method releasing the object.

Other tools help you track down problems related to **release** and **autorelease**:

- The **oh** command records allocation and deallocation events related to a specific process. It produces a report showing the stack frame for an object each time the object is allocated, copied, retained or released.
- The **AnalyzeAllocation** tool compiles statistics on memory allocation during the time a program executes.

See the man pages on these tools for more information.

Avoiding Deallocation Errors

Here's a few things to remember that might help you avoid deallocation bugs in OpenStep code:

- Make sure there's an **alloc**, **copy**, **mutableCopy**, or **retain** message sent to an object for each **release** or **autorelease** sent to it.
- When you release a collection object (such as an NSArray), you release all objects stored in it as well. When you request an object stored in a collection object, it's returned to you autoreleased.
- Superviews retain subviews as you add them to the view hierarchy and release subviews as you release them. If you want to keep swapped-out views, you should retain them. Similarly, when you replace a window's or box's content view, the old view is released and the new view is retained.
- To avoid retain cycles, objects should not retain their delegates. Objects also should not retain their outlets, since they do not own them.