Model-View-Controller

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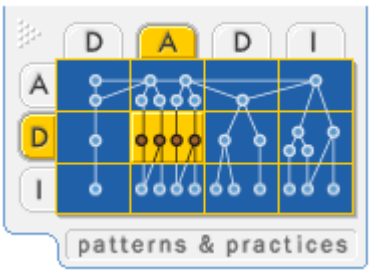

Version 1.0.1

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Context

The purpose of many computer systems is to retrieve data from a data store and display it for the user. After the user changes the data, the system stores the updates in the data store. Because the key flow of information is between the data store and the user interface, you might be inclined to tie these two pieces together to reduce the amount of coding and to improve application performance. However, this seemingly natural approach has some significant problems. One problem is that the user interface tends to change much more frequently than the data storage system. Another problem with coupling the data and user interface pieces is that business applications tend to incorporate business logic that goes far beyond data transmission.

Problem

How do you modularize the user interface functionality of a Web application so that you can easily modify the individual parts?

Forces

The following forces act on a system within this context and must be reconciled as you consider a solution to the problem:

User interface logic tends to change more frequently than business logic, especially in Web-based applications. For example, new user interface pages may be added, or existing page layouts may be shuffled around. After all, one of the advantages of a Web-based thin-client application is the fact that you can change the user interface at any time without having to redistribute the application. If presentation code and business logic are combined in a single object, you have to modify an object containing business logic every time you change the user interface. This is likely to introduce errors and require the retesting of all business logic after every minimal user interface change.

In some cases, the application displays the same data in different ways. For example, when an analyst prefers a spreadsheet view of data whereas management prefers a pie chart of the same data. In some rich-client user interfaces, multiple views of the same data are shown at the same time. If the user changes data in one view, the system must update all other views of the data automatically.

Designing visually appealing and efficient HTML pages generally requires a different skill set than does developing complex business logic. Rarely does a person have both skill sets. Therefore, it is desirable to separate the development effort of these two parts.

User interface activity generally consists of two parts: presentation and update. The presentation part retrieves data from a data source and formats the data for display. When the user performs an action based on the data, the update part passes control back to the business logic to update the data.

In Web applications, a single page request combines the processing of the action associated with the link that the user selected with the rendering of the target page. In many cases, the target page may not be directly related to the action. For example, imagine a simple Web application that shows a list of items. The user returns to the main list page after either adding an item to the list or deleting an item from the list. Therefore, the application must render the same page (the list) after executing two quite different

User interface code tends to be more device-dependent than business logic. If you want to migrate the application from a browser-based application to support personal digital assistants (PDAs) or Web-enabled cell phones, you must replace much of the user interface code, whereas the business logic may be unaffected. A clean separation of these two parts accelerates the migration and minimizes the risk of introducing errors into the business logic.

Creating automated tests for user interfaces is generally more difficult and time-consuming than for business logic. Therefore, reducing the amount of code that is directly tied to the user interface enhances the testability of the application.

Solution

The *Model-View-Controller (MVC)* pattern separates the modeling of the domain, the presentation, and the actions based on user input into three separate classes [Burbeck92]:

Model. The model manages the behavior and data of the application domain, responds to requests for information about its state (usually from the view), and responds to instructions to change state (usually from the controller).

View. The view manages the display of information.

Controller. The controller interprets the mouse and keyboard inputs from the user, informing the model and/or the view to change as appropriate.

Figure 1 depicts the structural relationship between the three objects.

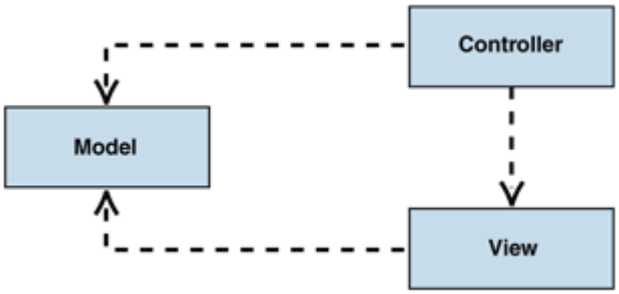

Figure 1: MVC class structure

It is important to note that both the view and the controller depend on the model. However, the model depends on neither the view nor the controller. This is one the key benefits of the separation. This separation allows the model to be built and tested

secondary in many rich-client applications, and, in fact, many user interface frameworks implement the roles as one object. In Web applications, on the other hand, the separation between view (the browser) and controller (the server-side components handling the HTTP request) is very well defined.

Model-View-Controller is a fundamental design pattern for the separation of user interface logic from business logic. Unfortunately, the popularity of the pattern has resulted in a number of faulty descriptions. In particular, the term "controller" has been used to mean different things in different contexts. Fortunately, the advent of Web applications has helped resolve some of the ambiguity because the separation between the view and the controller is so apparent.

Variations

In *Application Programming in Smalltalk-80: How to use Model-View-Controller (MVC)* [Burbeck92], Steve Burbeck describes two variations of *MVC*: a passive model and an active model.

The passive model is employed when one controller manipulates the model exclusively. The controller modifies the model and then informs the view that the model has changed and should be refreshed (see Figure 2). The model in this scenario is completely independent of the view and the controller, which means that there is no means for the model to report changes in its state. The HTTP protocol is an example of this. There is no simple way in the browser to get asynchronous updates from the server. The browser displays the view and responds to user input, but it does not detect changes in the data on the server. Only when the user explicitly requests a refresh is the server interrogated for changes.

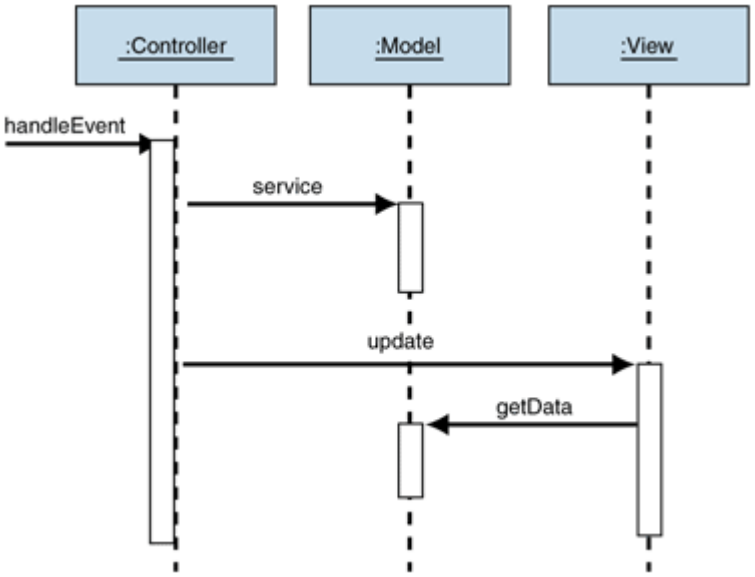

Figure 2: Behavior of the passive model

The active model is used when the model changes state without the controller's involvement. This can happen when other sources are changing the data and the changes must be reflected in the views. Consider a stock-ticker display. You receive stock data from an external source and want to update the views (for example, a ticker band and an alert window) when the stock data changes. Because only the model detects changes to its internal state when they occur, the model must notify the views to refresh the display.

However, one of the motivations of using the *MVC* pattern is to make the model independent from of the views. If the model had to notify the views of changes, you would reintroduce the dependency you were looking to avoid. Fortunately, the *Observer* pattern [Gamma95] provides a mechanism to alert other objects of state changes without introducing dependencies on them. The individual views implement the *Observer*interface and register with the model. The model tracks the list of all observers that subscribe to changes. When a model changes, the model iterates through all registered observers and notifies them of the change. This approach is often called "publish-subscribe." The model never requires specific information about any views. In fact, in scenarios where the controller needs to be informed of model changes (for example, to enable or disable menu options), all the controller has to do is implement the *Observer* interface and subscribe to the model changes. In situations where there are many views, it makes sense to define multiple subjects, each of which describes a specific type of model change. Each view can then subscribe only to types of changes that are relevant to the view.

Figure 3 shows the structure of the active MVC using *Observer* and how the observer

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