Course of Programming in Java: Model-View-Controller

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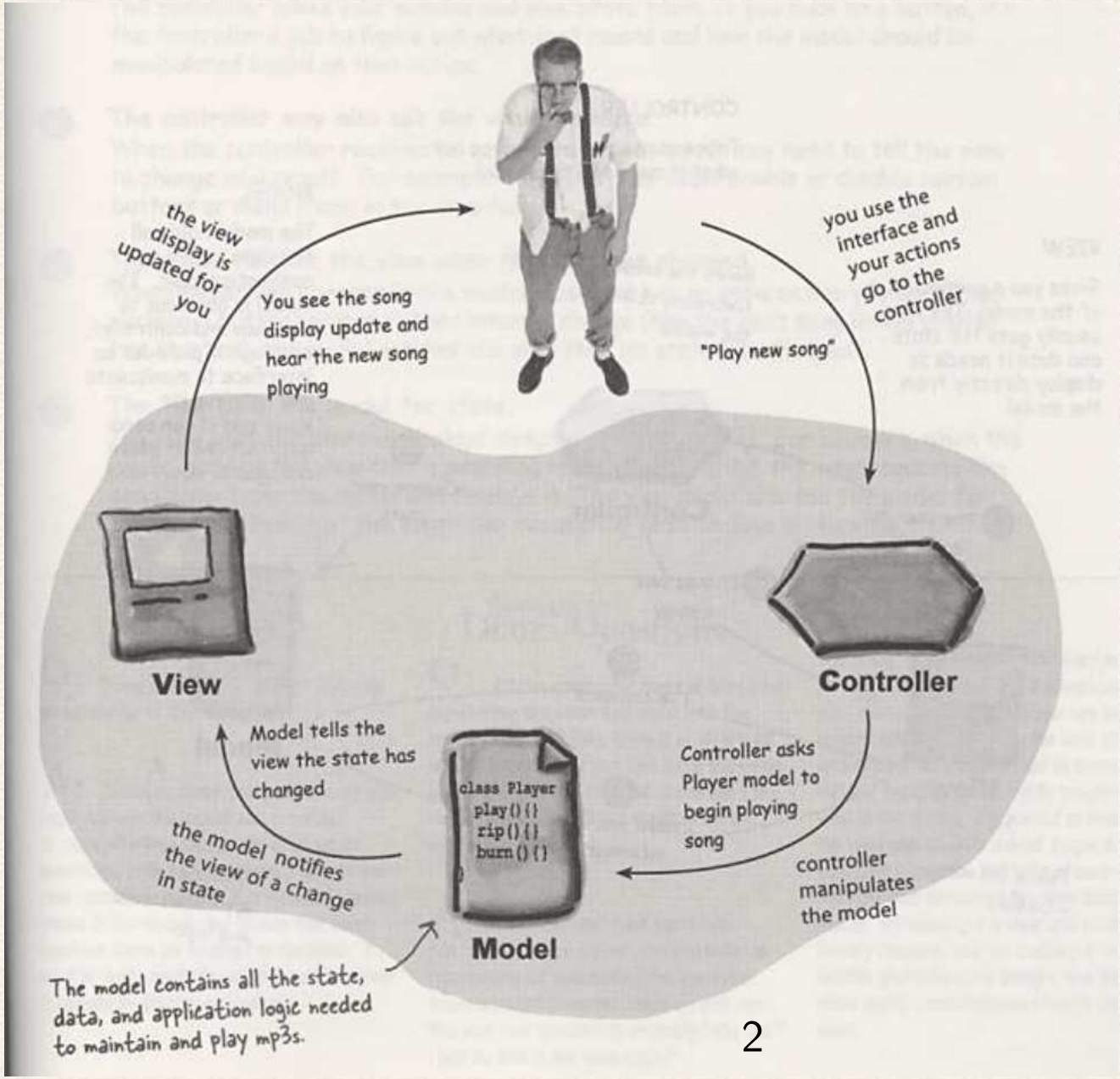
Head First Design Patterns

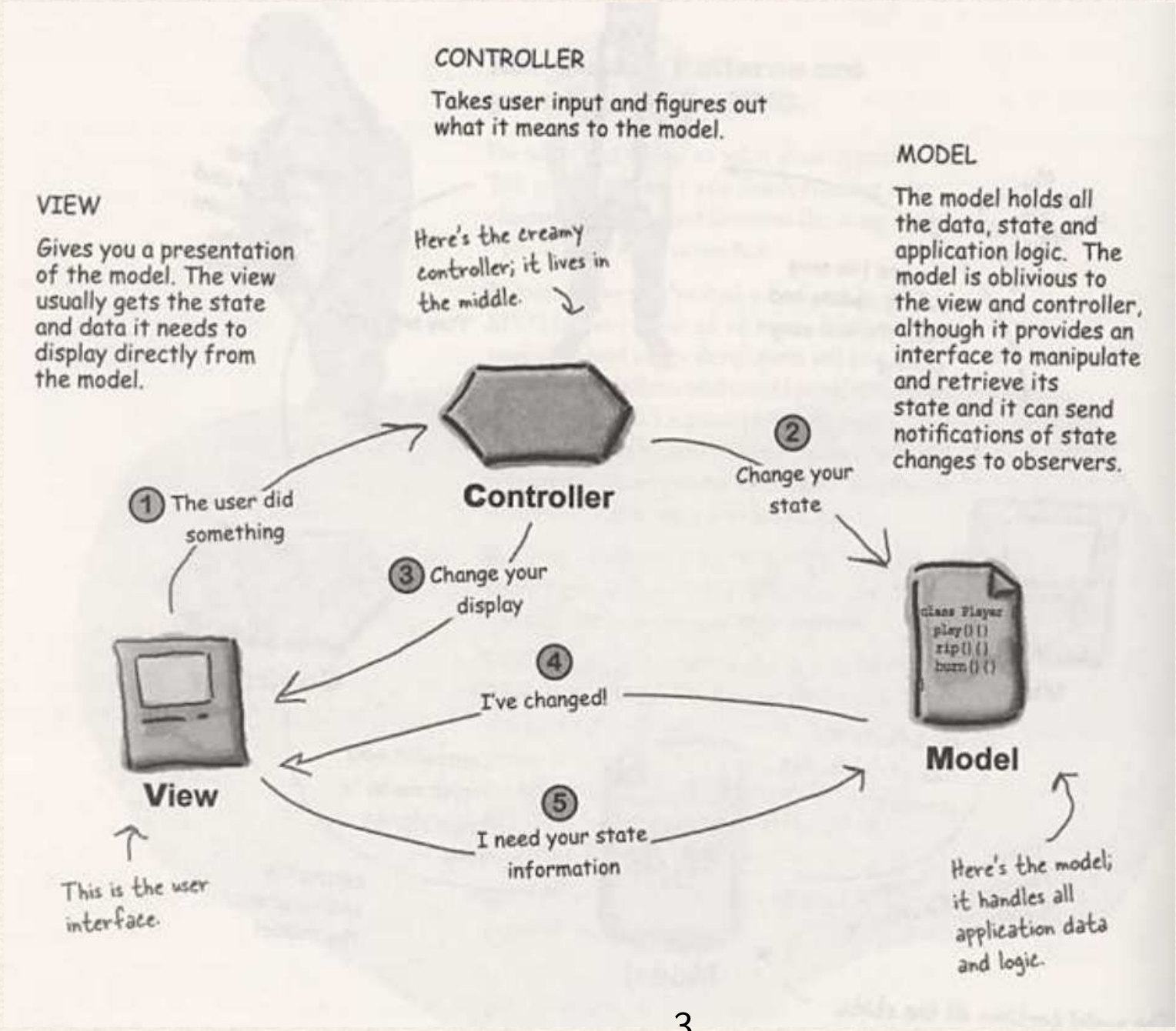
Chapter 12. Compound Patterns

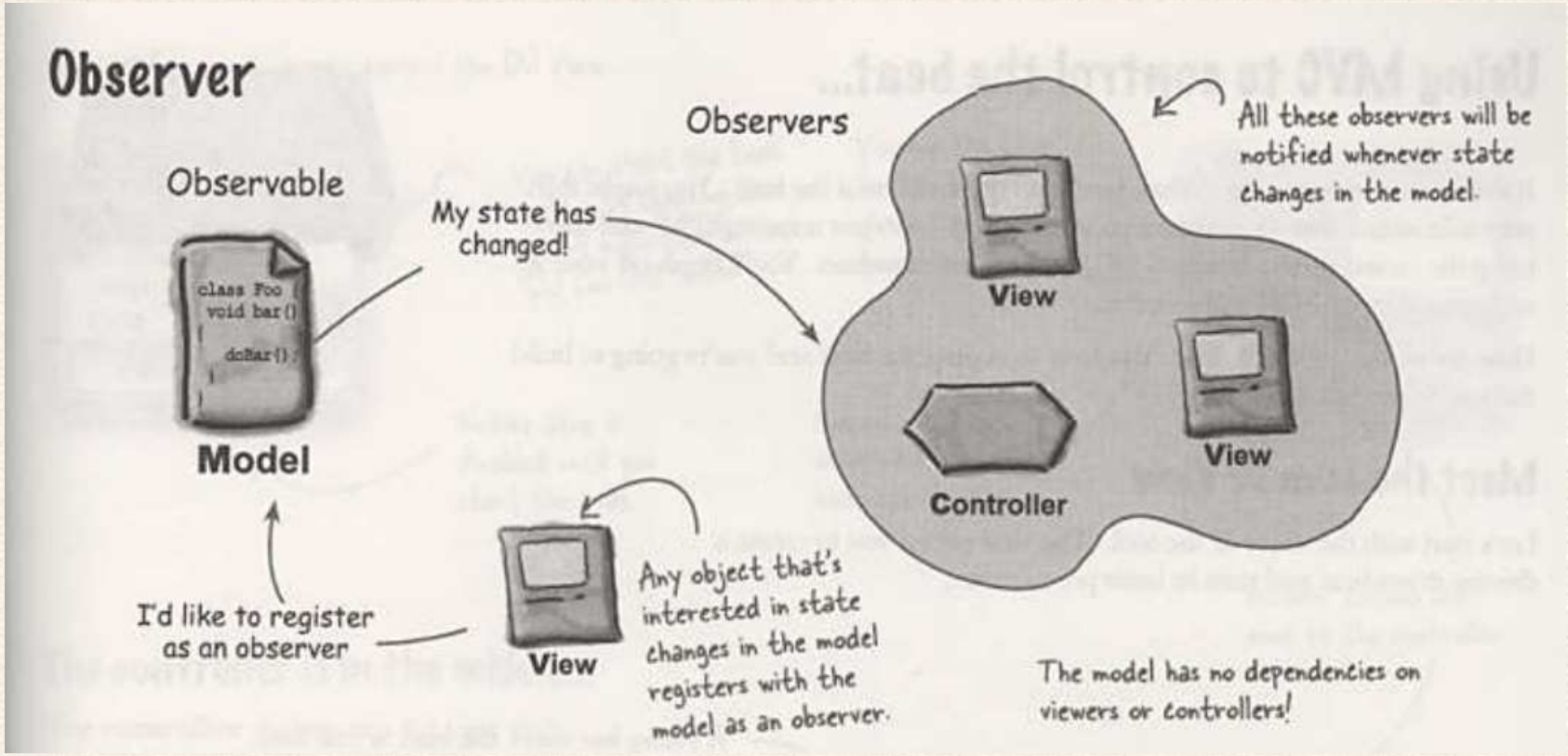
A Swing Architecture Overview

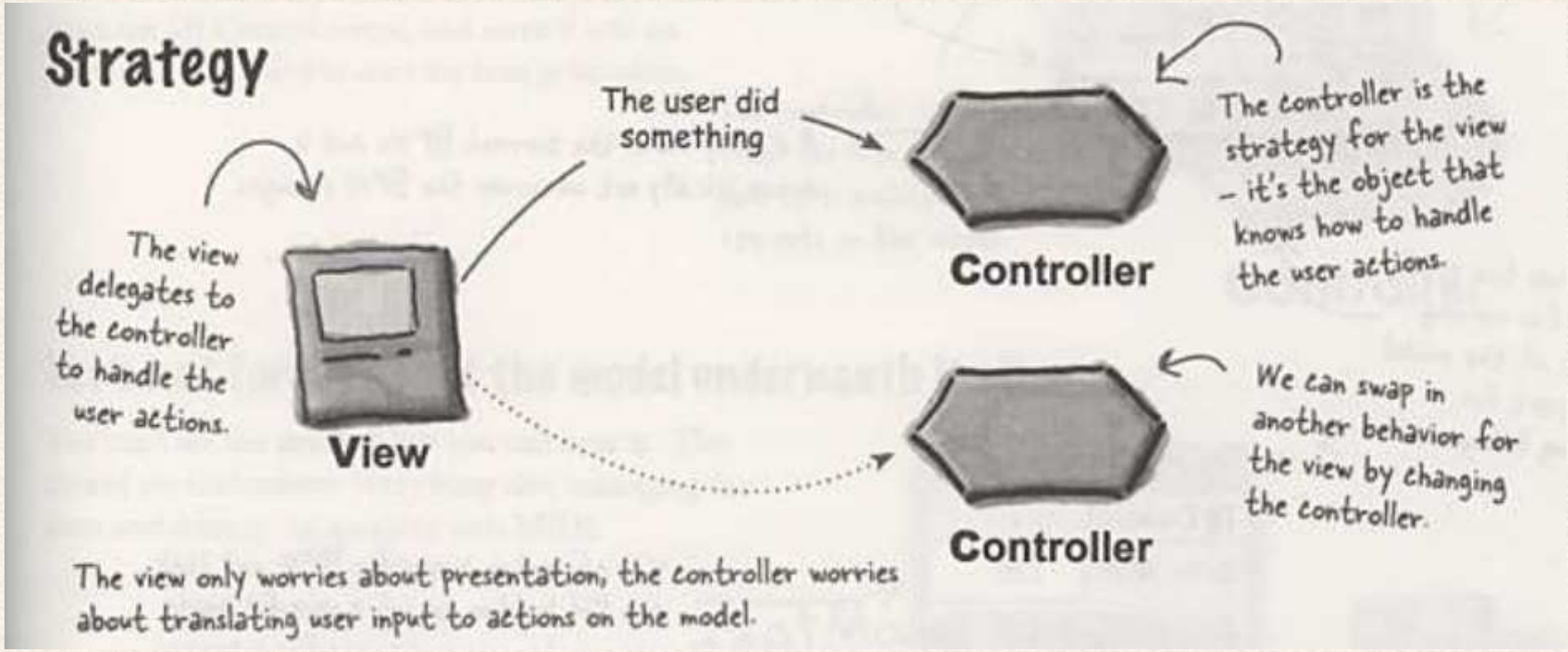
The Inside Story on JFC Component Design **By Amy Fowler**

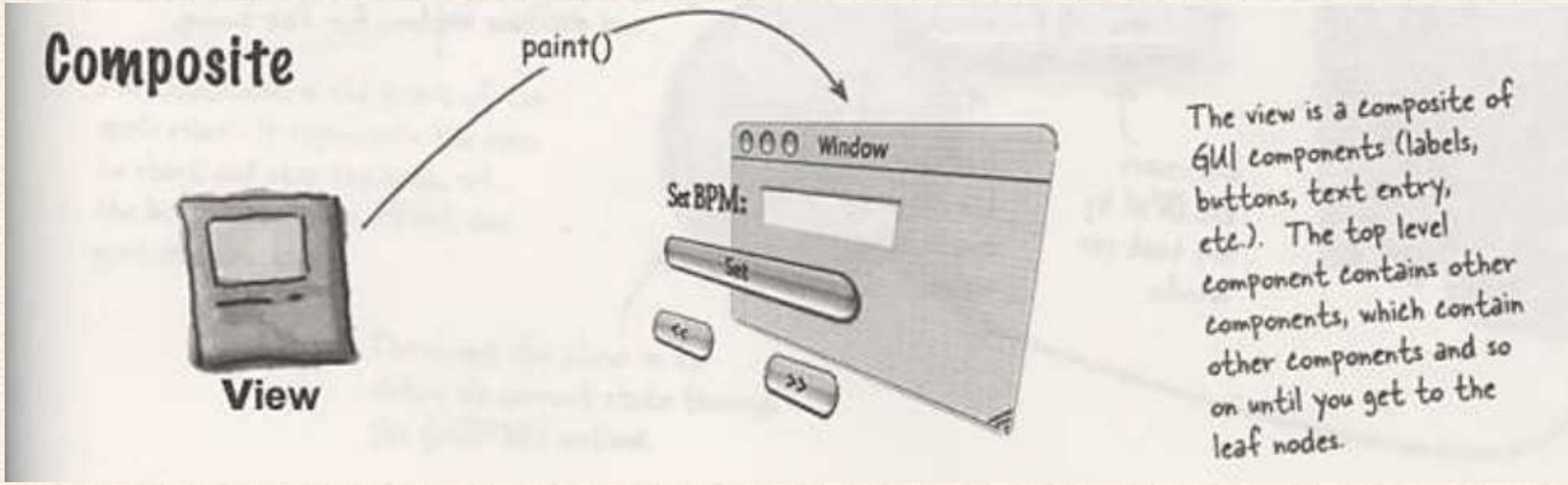
MVC from *Head First Design Patterns*



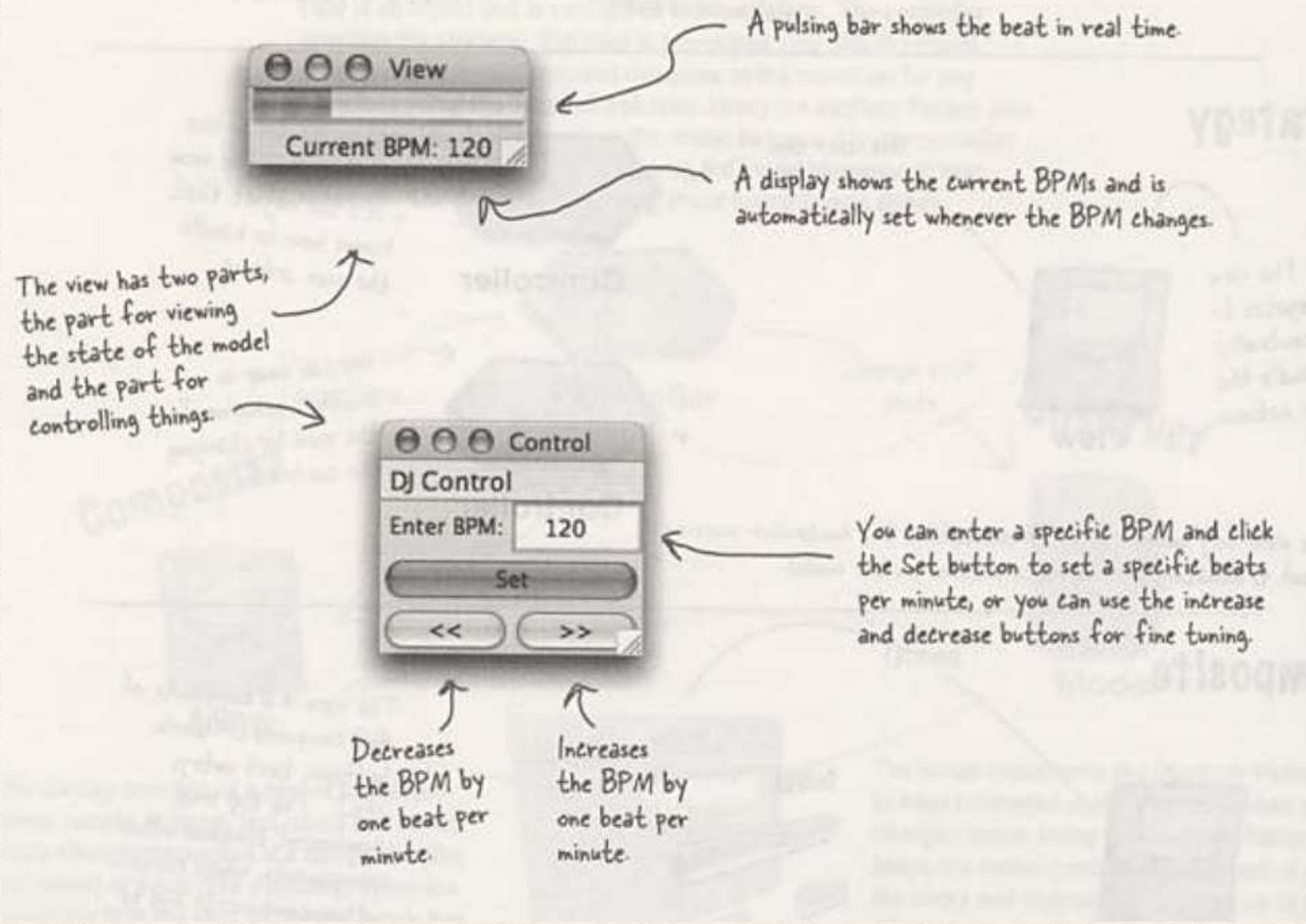

CONTROLLER
Takes user input and figures out what it means to the model.
VIEW
Gives you a presentation of the model. The view usually gets the state and data it needs to display directly from the model.
MODEL
The model holds all the data, state and application logic. The model is oblivious to the view and controller, although it provides an interface to manipulate and retrieve its state and it can send notifications of state changes to observers.
Here's the creamy controller; it lives in the middle.
Controller
1 The user did something
2 Change your state
3 Change your display
4 I've changed!
5 I need your state information
View
Model
class Player
play()()
rip()()
burn()()
This is the user interface.
Here's the model; it handles all application data and logic.

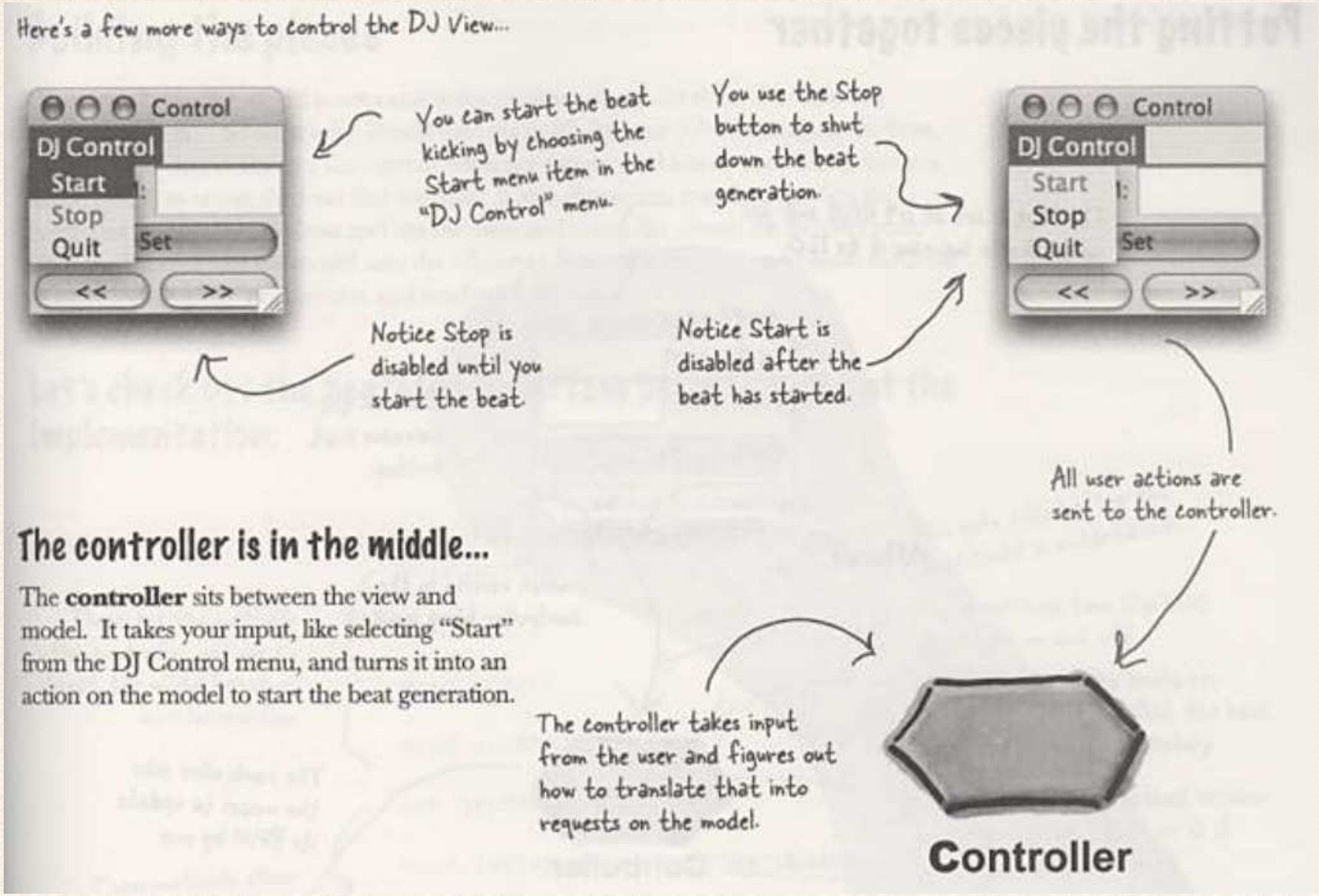

Observer
Observers
All these observers will be notified whenever state changes in the model.
Observable
My state has changed!
class Foo {
void bar() {
doBar();
}
}
Model
View
View
Controller
I'd like to register as an observer
View
Any object that's interested in state changes in the model registers with the model as an observer.
The model has no dependencies on viewers or controllers!


Strategy
The user did something
The controller is the strategy for the view – it's the object that knows how to handle the user actions.
Controller
The view delegates to the controller to handle the user actions.
View
We can swap in another behavior for the view by changing the controller.
Controller
The view only worries about presentation, the controller worries about translating user input to actions on the model.



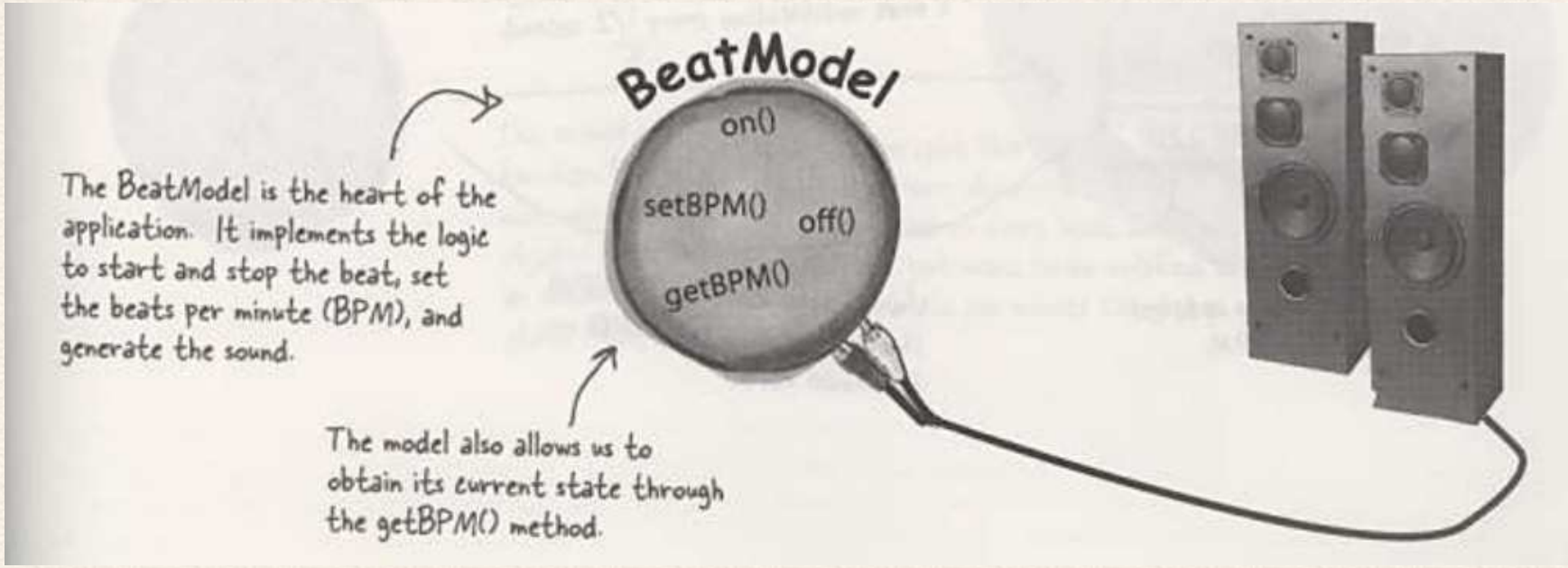
The view is a composite of GUI components (labels, buttons, text entry, etc.). The top level component contains other components, which contain other components and so on until you get to the leaf nodes.

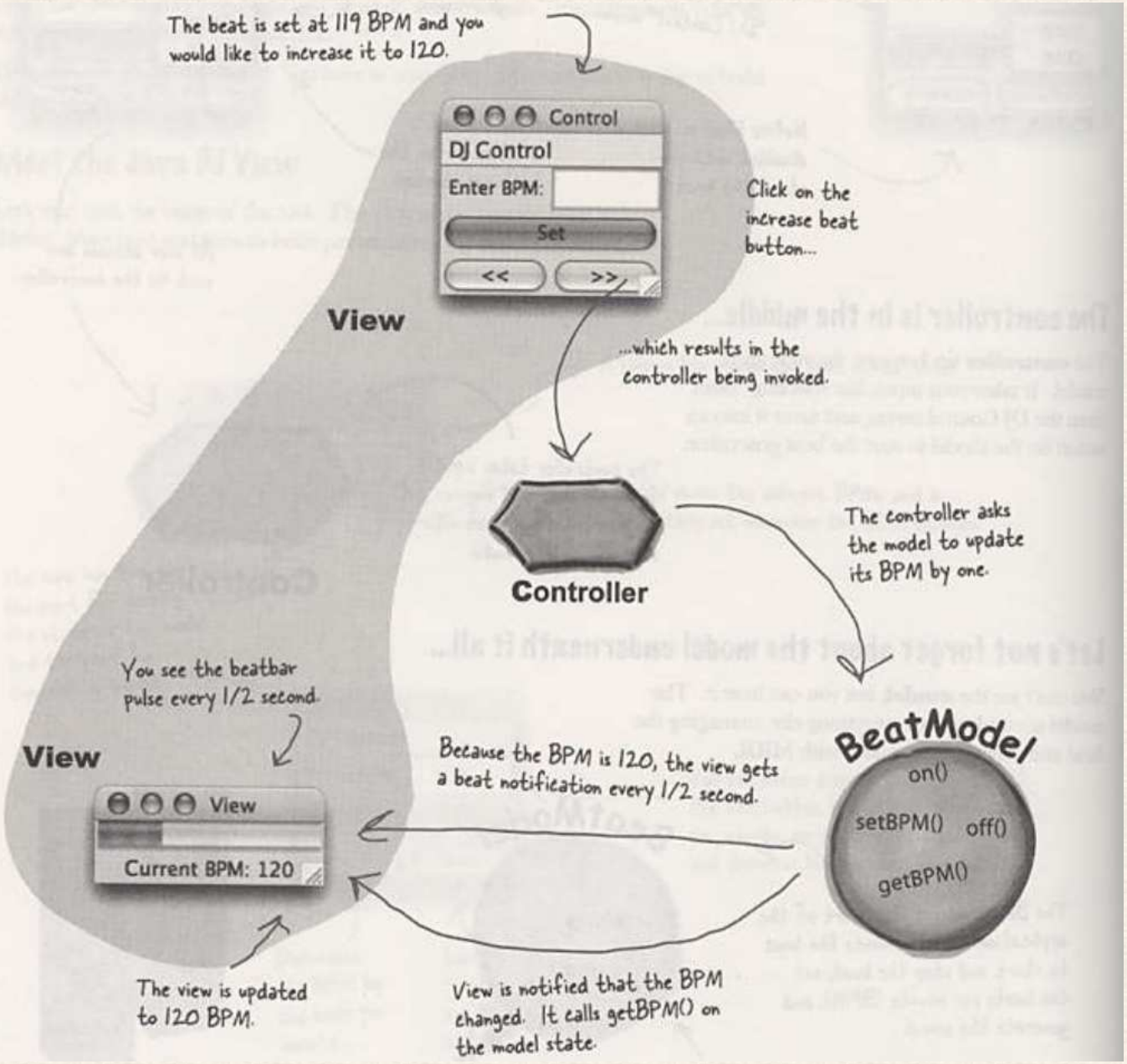

A pulsing bar shows the beat in real time.
View
Current BPM: 120
A display shows the current BPMs and is automatically set whenever the BPM changes.
The view has two parts, the part for viewing the state of the model and the part for controlling things.
Control
DJ Control
Enter BPM:
120
Set
<<
>>
You can enter a specific BPM and click the Set button to set a specific beats per minute, or you can use the increase and decrease buttons for fine tuning.
Decreases the BPM by one beat per minute.
Increases the BPM by one beat per minute.

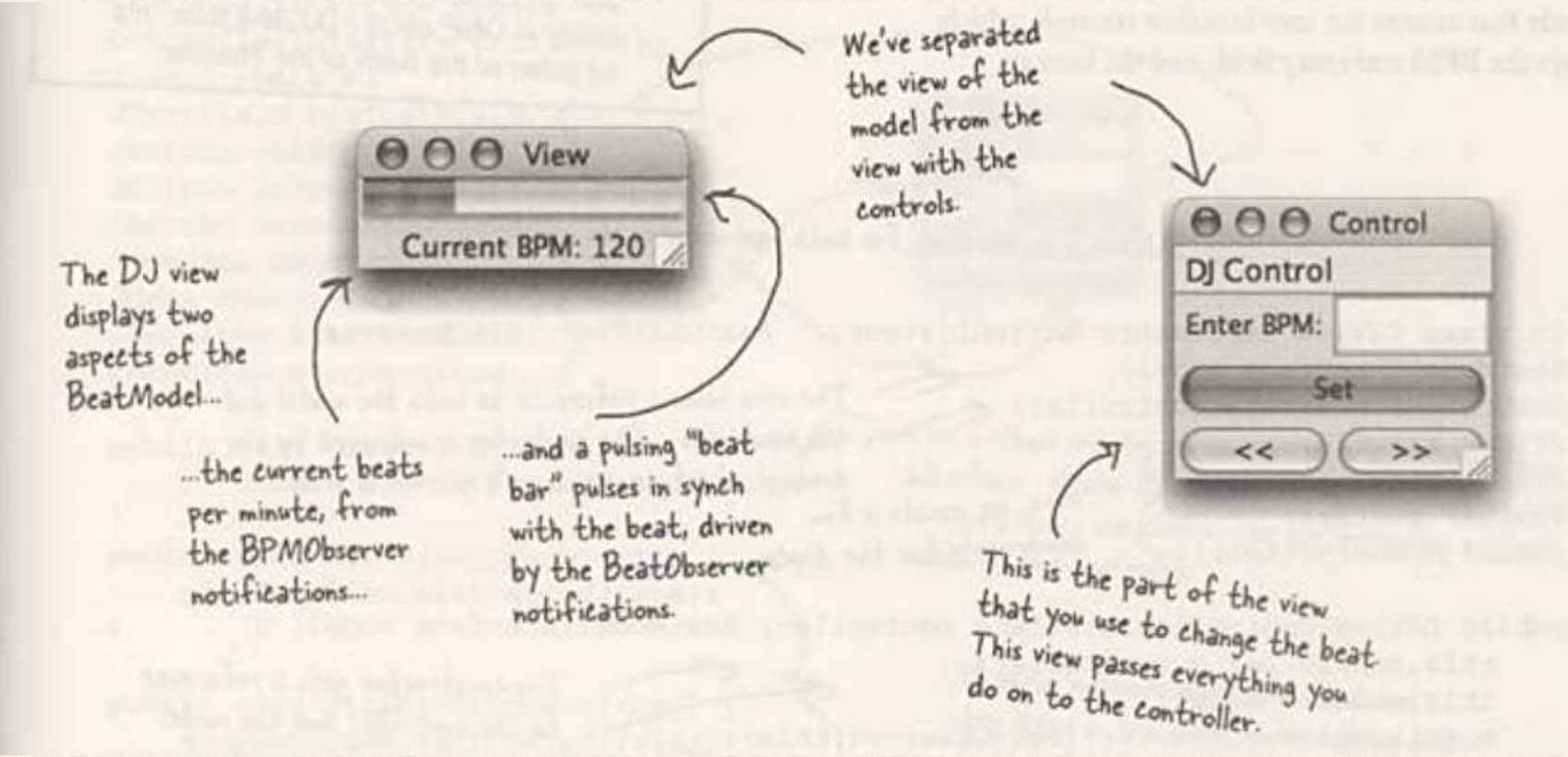


The controller is in the middle...

The **controller** sits between the view and model. It takes your input, like selecting "Start" from the DJ Control menu, and turns it into an action on the model to start the beat generation.


BeatModel
on()
setBPM()
off()
getBPM()
The BeatModel is the heart of the application. It implements the logic to start and stop the beat, set the beats per minute (BPM), and generate the sound.
The model also allows us to obtain its current state through the getBPM() method.


The beat is set at 119 BPM and you would like to increase it to 120.
Control
DJ Control
Enter BPM:
Set
<<
>>
Click on the increase beat button...
View
...which results in the controller being invoked.
Controller
The controller asks the model to update its BPM by one.
BeatModel
on()
setBPM()
off()
getBPM()
You see the beatbar pulse every 1/2 second.
View
View
Current BPM: 120
Because the BPM is 120, the view gets a beat notification every 1/2 second.
The view is updated to 120 BPM.
View is notified that the BPM changed. It calls getBPM() on the model state.


We've separated the view of the model from the view with the controls.
View
Current BPM: 120
Control
DJ Control
Enter BPM:
Set
<<
>>
The DJ view displays two aspects of the BeatModel...
...the current beats per minute, from the BPMObserver notifications...
...and a pulsing "beat bar" pulses in synch with the beat, driven by the BeatObserver notifications.
This is the part of the view that you use to change the beat. This view passes everything you do on to the controller.

DJ example: source code

- `BeatModelInterface.java`
- `BeatModel.java`
- `DJView.java`
- `ControllerInterface.java`
- `BeatController.java`
- `DJTestDrive.java`
- `HeartAdapter.java`
- `HeartController.java`
- `HeartTestDrive.java`

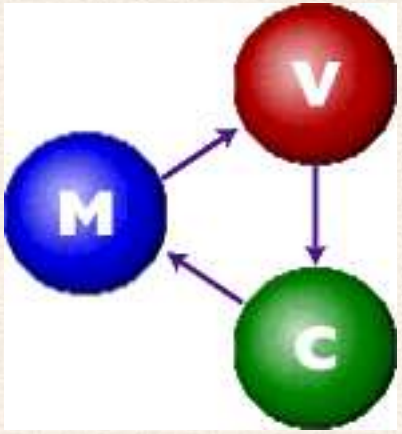
Design Goals

1. *Be implemented entirely in Java* to promote cross-platform consistency and easier maintenance.
2. *Provide a single API capable of supporting multiple look-and-feels* so that developers and end-users would not be locked into a single look-and-feel.
3. *Enable the power of model-driven programming* without requiring it in the highest-level API.
4. *Adhere to JavaBeans design principles* to ensure that components behave well in IDEs and builder tools.
5. *Provide compatibility with AWT APIs where there is overlapping, to leverage the AWT knowledge base and ease porting*.

Roots in MVC

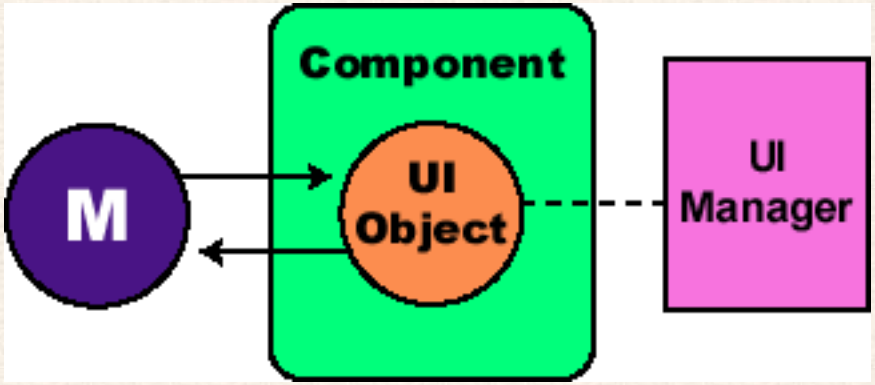
Swing architecture is rooted in the *model-view-controller* (*MVC*) design that dates back to SmallTalk. MVC architecture calls for a visual application to be broken up into three separate parts:

- A *model* that represents the data for the application.
- The *view* that is the visual representation of that data.
- A *controller* that takes user input on the view and translates that to changes in the model.



The delegate

We quickly discovered that MVC split didn't work well in practical terms because the view and controller parts of a component required a tight coupling (for example, it was very difficult to write a generic controller that didn't know specifics about the view). So we collapsed these two entities into a single UI (user-interface) object, as shown in this diagram:



The UI object shown in this picture is sometimes called *UI delegate*.

This new quasi-MVC design is sometimes referred to a *separable model architecture*.

To MVC or not to MVC?

- Component's view/controller responsibilities as being handled by the generic component class (such as. `JButton`, `JTree`, and so on).
  - E.g. the code that implements double-buffered painting is in Swing's `JComponent` class (the "mother" of most Swing component classes).
- Look-and-feel-specific aspects of those responsibilities to the UI object that is provided by the currently installed look-and-feel.
  - E.g. the code that renders a `JButton's` label is in the button's *UI delegate class*.

Separable model architecture

Swing defines a separate model interface for each component that has a logical *data* or *value* abstraction. This separation provides programs with the option of plugging in their own model implementations for Swing components.

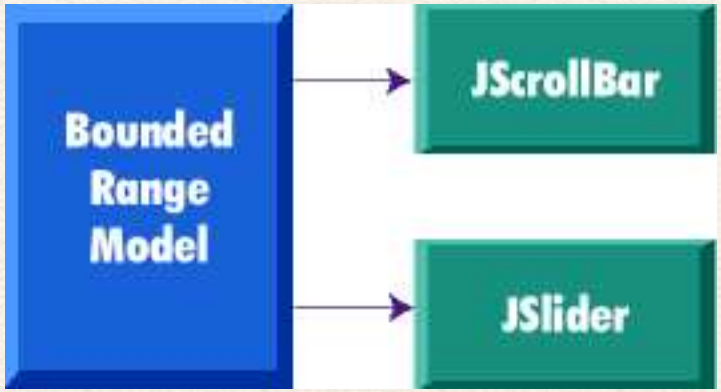
Component	Model Interface	Model Type
JButton	ButtonModel	GUI
JToggleButton	ButtonModel	GUI/data
JCheckBox	ButtonModel	GUI/data
JRadioButton	ButtonModel	GUI/data
JMenu	ButtonModel	GUI
JMenuItem	ButtonModel	GUI
JCheckBoxMenuItem	ButtonModel	GUI/data
JRadioButtonMenuItem	ButtonModel	GUI/data
JComboBox	ComboBoxModel	data
JProgressBar	BoundedRangeModel	GUI/data
JScrollBar	BoundedRangeModel	GUI/data
JSlider	BoundedRangeModel	GUI/data
JTabbedPane	SingleSelectionModel	GUI
JList	ListModel	data
JList	ListSelectionModel	GUI
JTable	TableModel	data
JTable	TableColumnModel	GUI
JTree	TreeModel	data
JTree	TreeSelectionModel	GUI
JEditorPane	Document	data
JTextPane	Document	data
JTextArea	Document	data
JTextField	Document	data
JPasswordField	Document	data

GUI-state vs. application-data models

- **GUI-state models** are interfaces that define the visual status of a GUI control, such as whether a button is pressed or armed, or which items are selected in a list.
- It is possible to manipulate the state of a GUI control through top-level methods on the component, without any direct interaction with the model at all.
- **Application-data models** are interfaces that represent some quantifiable data that has meaning primarily in the context of the application, such as the value of a cell in a table or the items displayed in a list.
- Provide clean separation between their application data/logic and their GUI. For truly data-centric Swing components, such as `JTree` and `JTable`, interaction with the data model is strongly recommended.
- For some components the model categorization falls in between GUI state models and application-data models, depending on the context in which the model is used. E.g. `BoundedRangeModel` on `JSlider` or `JProgressBar`.

Shared model definitions

Common models enable automatic connectability between component types. For example, because both `JSlider` and `JScrollbar` use the `BoundedRangeModel` interface, a single `BoundedRangeModel` instance could be plugged into both a `JScrollbar` and a `JSlider` and their visual state would always remain in sync.



The separable-model API

If you don't set your own model, a default is created and installed internally in the component. The naming convention for these default model classes is to prepend the interface name with "Default." For `JSlider`, a `DefaultBoundedRangeModel` object is instantiated in its constructor:

```
public JSlider(int orientation, int min, int max,
               int value) {
  checkOrientation(orientation);
  this.orientation = orientation;
  this.model =
     new DefaultBoundedRangeModel(value, 0, min, max);
  this.model.addChangeListener(changeListener);
  updateUI();
}
```

If a program subsequently calls `setModel()`, this default model is replaced, as in the following example:

```
JSlider slider = new JSlider();
BoundedRangeModel myModel =
  new DefaultBoundedRangeModel() {
     public void setValue(int n) {
        System.out.println("SetValue: "+ n);
        super.setValue(n);
     }
  });
slider.setModel(myModel);
```

For more complex models (such as those for `JTable` and `JList`), an abstract model implementation is also provided to enable developers to create their own models without starting from scratch. These classes are prepended with "Abstract".

For example, `JList's` model interface is `ListModel`, which provides both `DefaultListModel` and `AbstractListModel` classes.

Model change notification

Models must be able to notify any interested parties (such as views) when their data or value changes. Swing models use the *JavaBeans Event model*. There are two approaches for this notification used in Swing:

- Send a *lightweight notification* that the state has "changed" and require the listener to respond by sending a query back to the model to find out *what* has changed. The advantage of this approach is that a single event instance can be used for all notifications from a particular model – which is highly desirable when the notifications tend to be high in frequency (such as when a `JScrollBar` is dragged).
- Send a *stateful notification* that describes more precisely *how* the model has changed. This alternative requires a new event instance for each notification. It is desirable when a generic notification doesn't provide the listener with enough information to determine efficiently what has changed by querying the model (such as when a column of cells change value in a `JTable`).

Lightweight notification

The following models in Swing use the *lightweight notification*, which is based on the `ChangeListener/ChangeEvent` API:

Model	Listener	Event
BoundedRangeModel	ChangeListener	ChangeEvent
ButtonModel	ChangeListener	ChangeEvent
SingleSelectionModel	ChangeListener	ChangeEvent

The ChangeListener interface has a single generic method:

```
public void stateChanged(ChangeEvent e)
```

The only state in a ChangeEvent is the event "source."

Models that use this mechanism support the following methods to add and remove ChangeListeners:

```
public void addChangeListener(ChangeListener l)
public void removeChangeListener(ChangeListener l)
```

To be notified when the value of a `JSlider` has changed, e.g.:

```
JSlider slider = new JSlider();
BoundedRangeModel model = slider.getModel();
model.addChangeListener(new ChangeListener() {
  public void stateChanged(ChangeEvent e) {
     // need to query the model to get updated value...
     BoundedRangeModel m =
        (BoundedRangeModel)e.getSource();
     System.out.println("model changed: " + m.getValue());
  }
});
```

To provide convenience for programs that don't wish to deal with separate model objects, some Swing component classes also provide the ability to register ChangeListeners directly on the component (so the component can listen for changes on the model internally and then propagates those events to any listeners registered directly on the component).

So we could simplify the preceding example to:

```
JSlider slider = new JSlider();
slider.addChangeListener(new ChangeListener() {
  public void stateChanged(ChangeEvent e) {
     // the source will be the slider this time...
     JSlider s = (JSlider)e.getSource();
     System.out.println("value changed: " + s.getValue());
  }
});
```

Stateful notification

Models that support *stateful notification* provide event `Listener` interfaces and event objects specific to their purpose. The following table shows the breakdown for those models:

Model	Listener	Event
ListModel	ListDataListener	ListDataEvent
ListSelectionModel	ListSelectionListener	ListSelectionEvent
ComboBoxModel	ListDataListener	ListDataEvent
TreeModel	TreeModelListener	TreeModelEvent
TreeSelectionModel	TreeSelectionListener	TreeSelectionEvent
TableModel	TableModelListener	TableModelEvent
TableColumnModel	TableColumnModel-Listener	TableColumnModel-Event
Document	DocumentListener	DocumentEvent
Document	UndoableEditListener	UndoableEditEvent

The following code dynamically tracks the selected item in a JList:

```
String items[] = {"One", "Two", "Three");
JList list = new JList(items);
ListSelectionModel sModel = list.getSelectionModel();
sModel.addListSelectionListener
      (new ListSelectionListener() {
  public void valueChanged(ListSelectionEvent e) {
     // get change information directly
     // from the event instance...
     if (!e.getValueIsAdjusting()) {
        System.out.println("selection changed: " +
          e.getFirstIndex());
     }
  }
});
```

Ignoring models completely

As mentioned previously, most components provide the model-defined API directly in the component class so that the component can be manipulated without interacting with the model at all. This is considered perfectly acceptable programming practice (especially for the GUI-state models). For example, following is `JSlider`'s implementation of `getValue()`, which internally delegates the method call to its model:

```
public int getValue() {
   return getModel().getValue();
}
```

And so programs can simply do the following:

```
JSlider slider = new JSlider();
int value = slider.getValue();
//what's a "model," anyway?
```

Pluggable look-and-feel architecture

A new L&F is a very powerful feature for a subset of applications that want to create a unique identity. PL&F is also ideally suited for use in building GUIs that are accessible to users with disabilities, such as visually impaired users or users who cannot operate a mouse.

In a nutshell, pluggable look-and-feel design simply means that the portion of a component's implementation that deals with the presentation (the look) and event-handling (the feel) is delegated to a separate UI object supplied by the currently installed look-and-feel, which can be changed at runtime.

Look-and-feel management

The UIManager is the API through which components and programs access look-and-feel information (they should rarely, if ever, talk directly to a `LookAndFeel` instance). `UIManager` is responsible for keeping track of which `LookAndFeel` classes are available, which are installed, and which is currently the default. The `UIManager` also manages access to the Defaults Table for the current look-and-feel.

```
public static LookAndFeel getLookAndFeel()
public static void
    setLookAndFeel(LookAndFeel newLookAndFeel)
public static void setLookAndFeel(String className)
```

As a default look-and-feel, Swing initializes the cross-platform Java look and feel (formerly known as "Metal"). The following code sample will set the default Look-and-Feel to be CDE/Motif:

```
UIManager.setLookAndFeel(
  "com.sun.java.swing.plaf.motif.MotifLookAndFeel");
```

The `UIManager` static methods to programmatically obtain the appropriate `LookAndFeel` class names:

```
public static String
    getSystemLookAndFeelClassName()
public static String
    getCrossPlatformLookAndFeelClassName()
```

So, to ensure that a program always runs in the platform's system look-and-feel, the code might look like this:

```
UIManager.setLookAndFeel(
  UIManager.getSystemLookAndFeelClassName());
```

Dynamically Changing the Default Look-and-Feel

When a Swing application programmatically sets the look-and-feel (as described above), the ideal place to do so is *before any Swing components are instantiated*. This is because the `UIManager.setLookAndFeel()` method makes a particular `LookAndFeel` the current default by loading and initializing that `LookAndFeel` instance, but it does *not* automatically cause any existing components to change their look-and-feel.

And so if a program needs to change the look-and-feel of a GUI hierarchy after it was instantiated, the code might look like the following:

```
// GUI already instantiated, where myframe
// is top-level frame
try {
  UIManager.setLookAndFeel(
    "com.sun.java.swing.plaf.motif.MotifLookAndFeel");
  myframe.setCursor(
        Cursor.getPredefinedCursor(Cursor.WAIT_CURSOR));
  SwingUtilities.updateComponentTreeUI(myframe);
  myframe.validate();
} catch (UnsupportedLookAndFeelException e) {
} finally {
  myframe.setCursor
        (Cursor.getPredefinedCursor
            (Cursor.DEFAULT_CURSOR));
}
```

`public static LookAndFeelInfo[] getInstalledLookAndFeels()` method can be used to programmatically determine which look-and-feel implementations are available, which is useful when building user interfaces which allow the end-user to dynamically select a look-and-feel.