

the *model view controller* song

The King of Compound Patterns

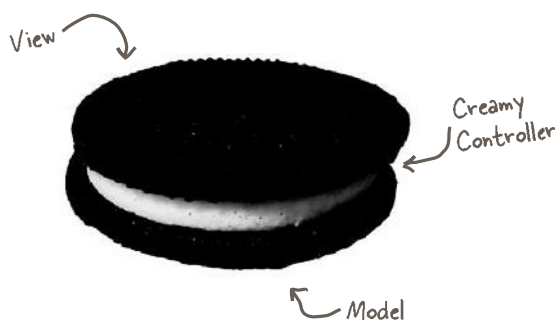
If Elvis were a compound pattern, his name would be **Model-View-Controller**, and he'd be singing a little song like this...

Model, View, Controller

Lyrics and music by James Dempsey.

MVC's a paradigm for factoring your code
into functional segments, so your brain does not explode.
To achieve reusability, you gotta keep those boundaries
clean

Model on the one side, View on the other, the
Controller's in between.



Model View, it's got three layers like Oreos do

Model View Controller

Model View, Model View, Model View Controller

Model objects represent your application's *raison d'être*
Custom objects that contain data, logic, and et cetera
You create custom classes, in your app's problem domain
you can choose to reuse them with all the views
but the model objects stay the same.

You can model a throttle and a manifold

Model the toddle of a two year old

Model a bottle of fine Chardonnay

Model all the glottal stops people say

Model the coddling of boiling eggs

You can model the waddle in Hexley's legs

Model View, you can model all the models that pose for
GQ

Model View Controller

View objects tend to be controls used to display and edit
Cocoa's got a lot of those, well written to its credit.
Take an `NSTextView`, hand it any old Unicode string
The user can interact with it, it can hold most anything
But the view don't know about the Model
That string could be a phone number or the works of
Aristotle

Keep the coupling loose

and so achieve a massive level of reuse

Model View, all rendered very nicely in Aqua blue

Model View Controller

You're probably wondering now

You're probably wondering how

Data flows between Model and View

The Controller has to mediate

Between each layer's changing state

To synchronize the data of the two



compound patterns

It pulls and pushes every changed value

Model View, mad props to the smalltalk crew!
Model View Controller

Model View, it's pronounced Oh Oh not Ooo Ooo
Model View Controller

There's a little left to this story
A few more miles upon this road
Nobody seems to get much glory
From writing the controller code

Well the model's mission critical
And gorgeous is the view
I might be lazy, but sometimes it's just crazy
How much code I write is just glue
And it wouldn't be so tragic
But the code ain't doing magic
It's just moving values through

And I don't mean to be vicious
But it gets repetitious
Doing all the things controllers do

And I wish I had a dime
For every single time


I sent a TextField StringValue.

Model View
How we gonna deep six all that glue
Model View Controller

Controllers know the Model and View very intimately
They often use hardcoding which can be foreboding for
reusability
But now you can connect each model key that you select
to any view property

And once you start binding
I think you'll be finding less code in your source tree

Yeah I know I was elated by the stuff they've automated
and the things you get for free

And I think it bears repeating
all the code you won't be needing
when you hook it up in ~~FB~~  Using Swing

Model View, even handles multiple selections too
Model View Controller

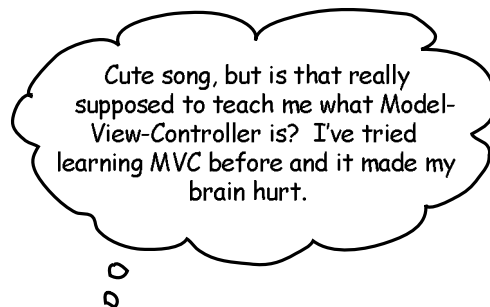
Model View, bet I ship my application before you
Model View Controller



Don't just read! After all this is a Head First book... grab your iPod, hit this URL:
<http://www.headfirstlabs.com/books/hfdp/media.html>
Sit back and give it a listen.



mvc is patterns put together



No. Design Patterns are your key to the MVC.

We were just trying to whet your appetite. Tell you what, after you finish reading this chapter, go back and listen to the song again – you'll have even more fun.

It sounds like you've had a bad run in with MVC before? Most of us have. You've probably had other developers tell you it's changed their lives and could possibly create world peace. It's a powerful compound pattern, for sure, and while we can't claim it will create world peace, it will save you hours of writing code once you know it.

But first you have to learn it, right? Well, there's going to be a big difference this time around because *now you know patterns!*

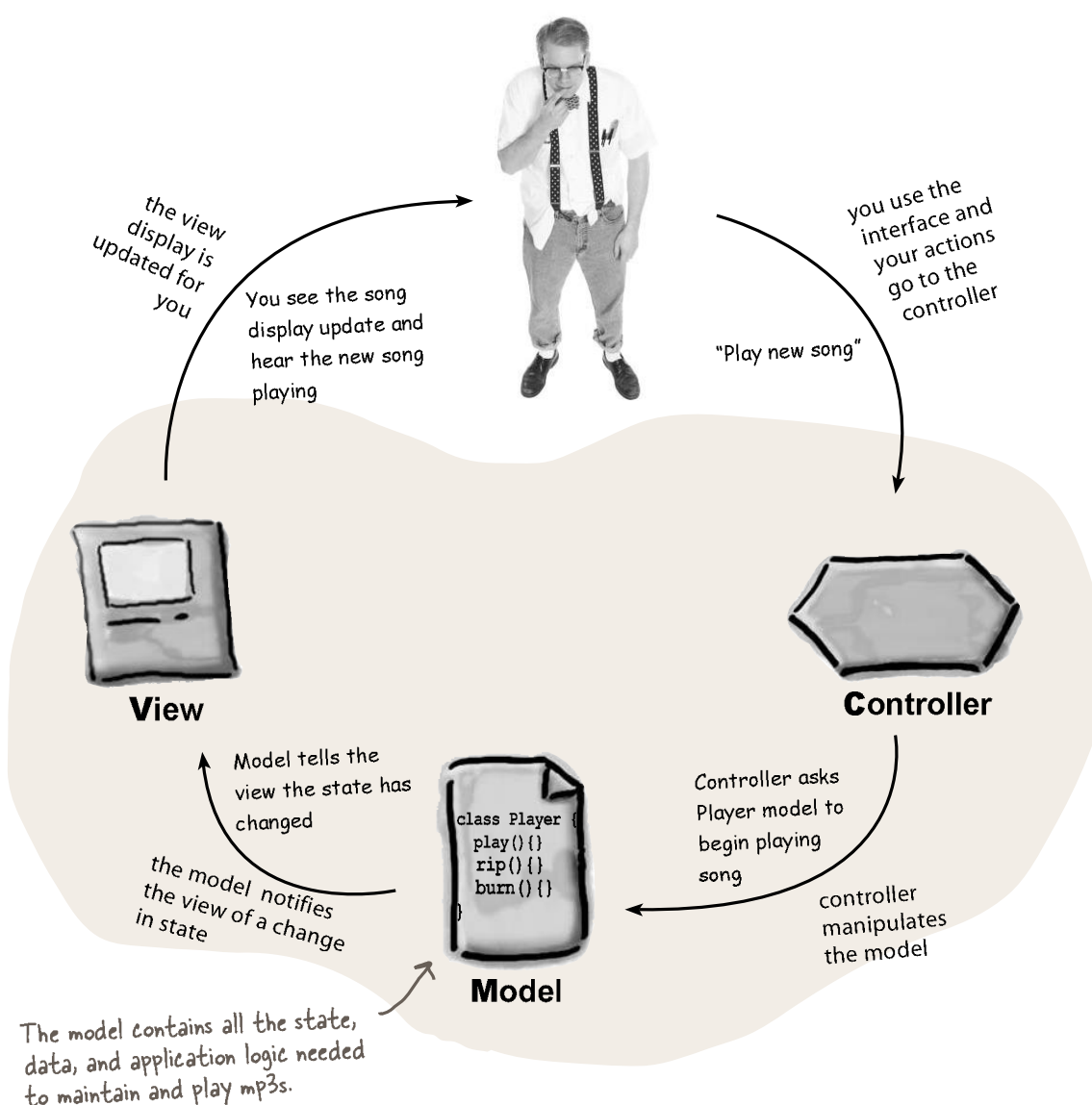
That's right, patterns are the key to MVC. Learning MVC from the top down is difficult; not many developers succeed. Here's the secret to learning MVC: *it's just a few patterns put together.* When you approach learning MVC by looking at the patterns, all of the sudden it starts to make sense.

Let's get started. This time around you're going to nail MVC!

Meet the Model-View-Controller

Imagine you're using your favorite MP3 player, like iTunes. You can use its interface to add new songs, manage playlists and rename tracks. The player takes care of maintaining a little database of all your songs along with their associated names and data. It also takes care of playing the songs and, as it does, the user interface is constantly updated with the current song title, the running time, and so on.

Well, underneath it all sits the Model-View-Controller..

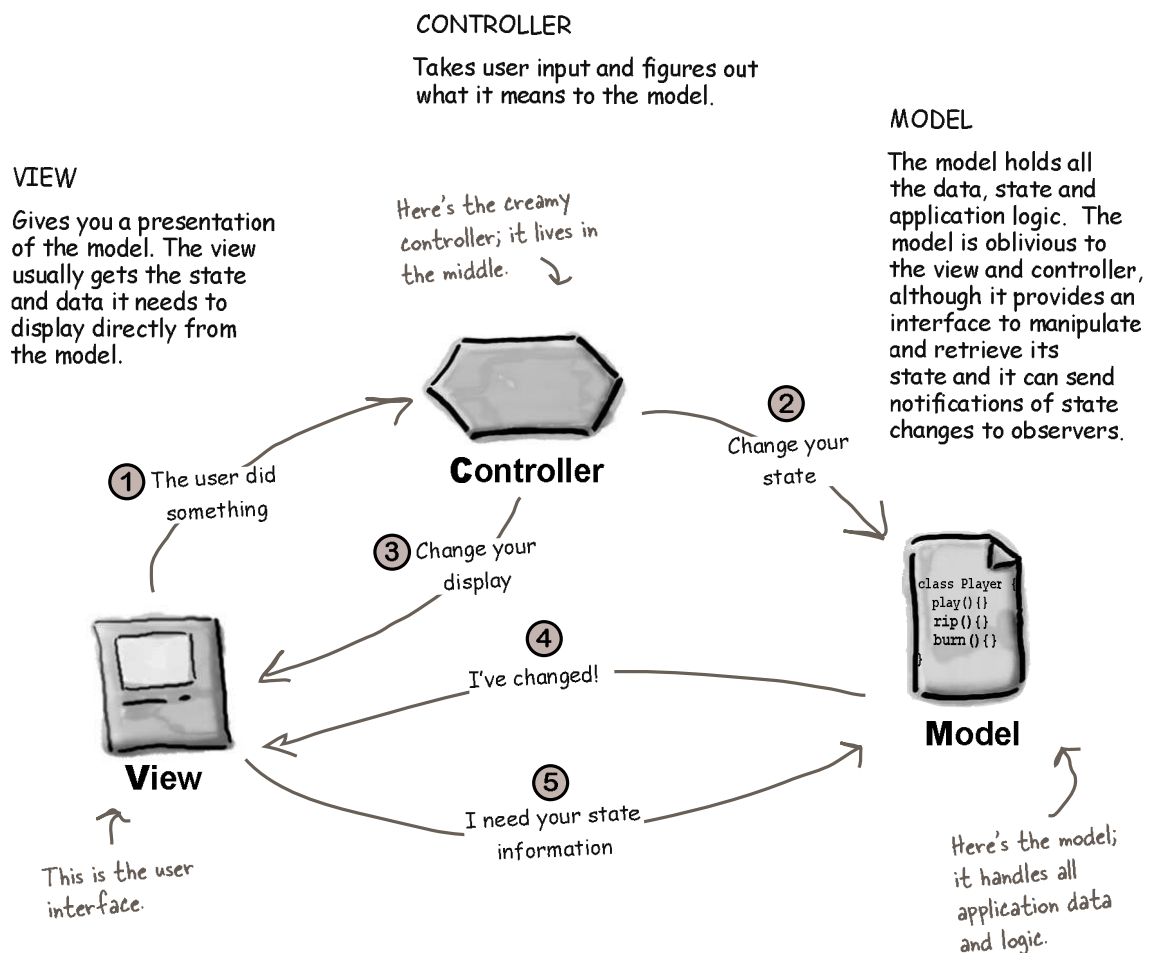


mvc up close

Now let's zoom into the

A closer look...

The MP3 Player description gives us a high level view of MVC, but it really doesn't help you understand the nitty gritty of how the compound pattern works, how you'd build one yourself, or why it's such a good thing. Let's start by stepping through the relationships among the model, view and controller, and then we'll take second look from the perspective of Design Patterns.





compound patterns

- ① **You're the user — you interact with the view.**
The view is your window to the model. When you do something to the view (like click the Play button) then the view tells the controller what you did. It's the controller's job to handle that.
- ② **The controller asks the model to change its state.**
The controller takes your actions and interprets them. If you click on a button, it's the controller's job to figure out what that means and how the model should be manipulated based on that action.
- ③ **The controller may also ask the view to change.**
When the controller receives an action from the view, it may need to tell the view to change as a result. For example, the controller could enable or disable certain buttons or menu items in the interface.
- ④ **The model notifies the view when its state has changed.**
When something changes in the model, based either on some action you took (like clicking a button) or some other internal change (like the next song in the playlist has started), the model notifies the view that its state has changed.
- ⑤ **The view asks the model for state.**
The view gets the state it displays directly from the model. For instance, when the model notifies the view that a new song has started playing, the view requests the song name from the model and displays it. The view might also ask the model for state as the result of the controller requesting some change in the view.

there are no Dumb Questions

Q: Does the controller ever become an observer of the model?

A: Sure. In some designs the controller registers with the model and is notified of changes. This can be the case when something in the model directly affects the user interface controls. For instance, certain states in the model may dictate that some interface items be enabled or disabled. If so, it is really controller's job to ask the view to update its display accordingly.

Q: All the controller does is take user input from the view and send it to the model, correct? Why have it at all if that is all it does? Why not just have the code in the view itself? In most cases isn't the controller just calling a method on the model?

A: The controller does more than just "send it to the model", the controller is responsible for interpreting the input and manipulating the model based on that input. But your real question is probably "why can't I just do that in the view code?"

You could; however, you don't want to for two reasons: First, you'll complicate your view code because it now has two responsibilities: managing the user interface and dealing with logic of how to control the model. Second, you're tightly coupling your view to the model. If you want to reuse the view with another model, forget it. The controller separates the logic of control from the view and decouples the view from the model. By keeping the view and controller loosely coupled, you are building a more flexible and extensible design, one that can more easily accommodate change down the road.

the patterns in mvc

Looking at MVC through patterns-colored glasses

We've already told you the best path to learning the MVC is to see it for what it is: a set of patterns working together in the same design.

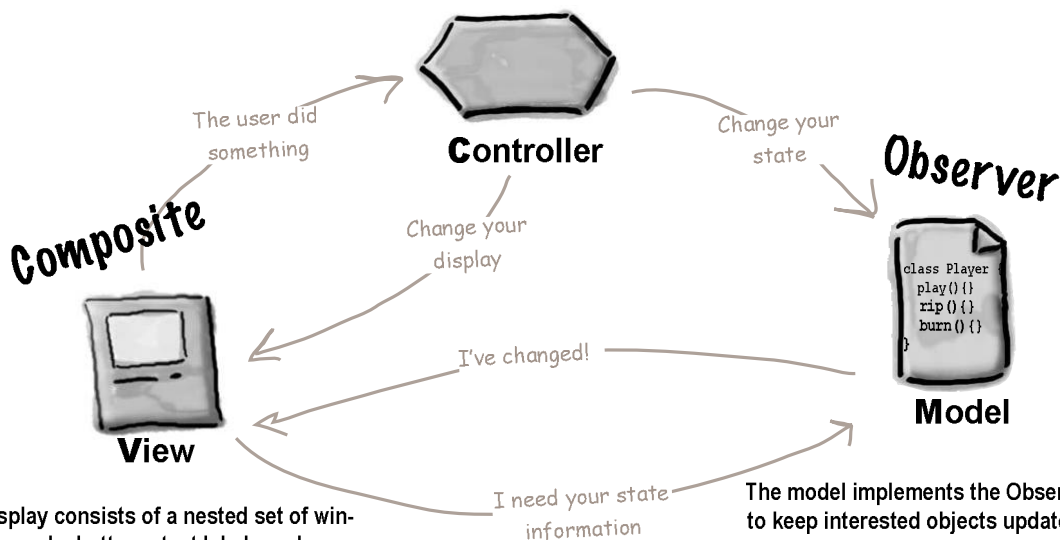
Let's start with the model. As you might have guessed the model uses Observer to keep the views and controllers updated on the latest state changes. The view and the controller, on the other hand, implement the Strategy Pattern. The controller is the behavior of the view, and it can be easily exchanged with another controller if you want different behavior. The view itself also uses a pattern internally to manage the windows, buttons and other components of the display: the Composite Pattern.

Let's take a closer look:



Strategy

The view and controller implement the classic Strategy Pattern: the view is an object that is configured with a strategy. The controller provides the strategy. The view is concerned only with the visual aspects of the application, and delegates to the controller for any decisions about the interface behavior. Using the Strategy Pattern also keeps the view decoupled from the model because it is the controller that is responsible for interacting with the model to carry out user requests. The view knows nothing about how this gets done.

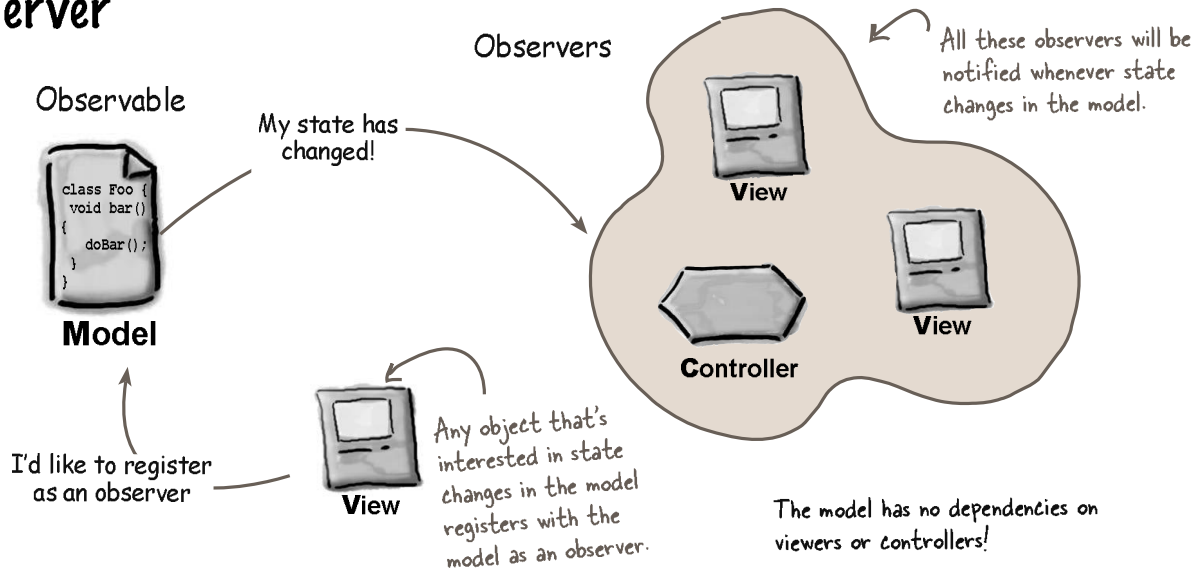


The display consists of a nested set of windows, panels, buttons, text labels and so on. Each display component is a composite (like a window) or a leaf (like a button). When the controller tells the view to update, it only has to tell the top view component, and Composite takes care of the rest.

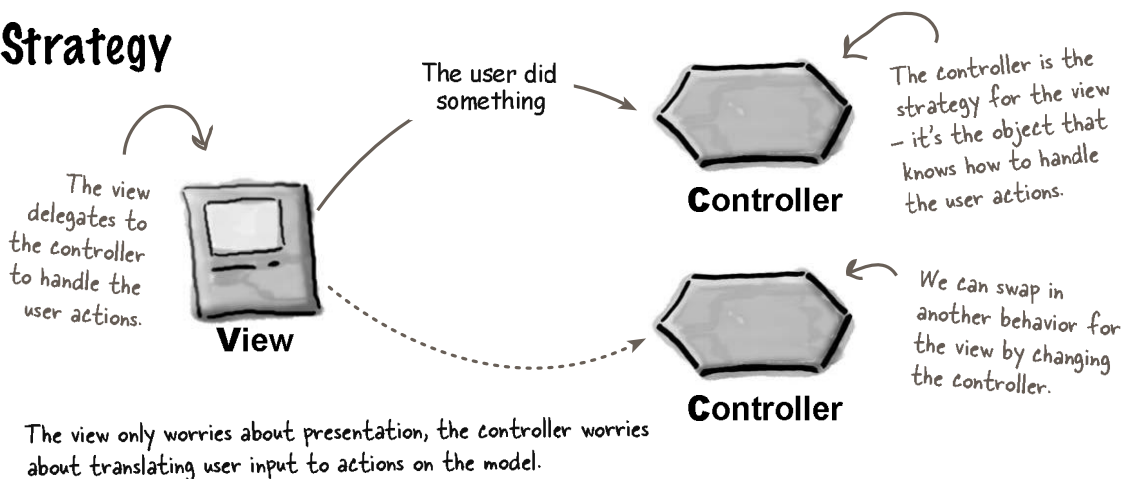
The model implements the Observer Pattern to keep interested objects updated when state changes occur. Using the Observer Pattern keeps the model completely independent of the views and controllers. It allows us to use different views with the same model, or even use multiple views at once.

compound patterns

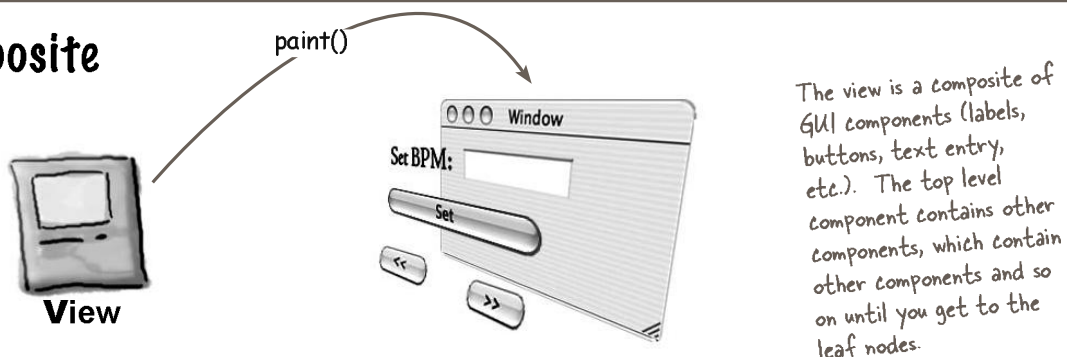
Observer



Strategy



Composite



mvc and the dj view

Using MVC to control the beat...

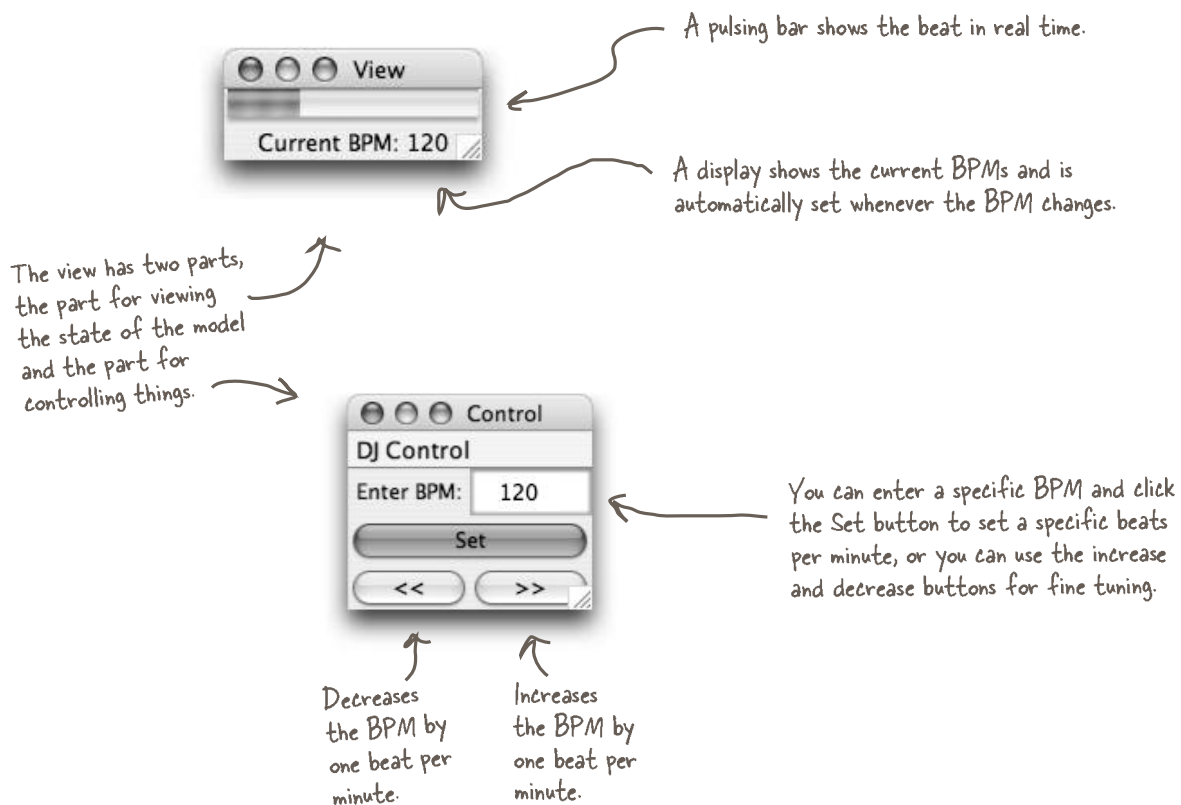
It's your time to be the DJ. When you're a DJ it's all about the beat. You might start your mix with a slowed, downtempo groove at 95 beats per minute (BPM) and then bring the crowd up to a frenzied 140 BPM of trance techno. You'll finish off your set with a mellow 80 BPM ambient mix.

How are you going to do that? You have to control the beat and you're going to build the tool to get you there.



Meet the Java DJ View

Let's start with the **view** of the tool. The view allows you to create a driving drum beat and tune its beats per minute...





compound patterns

Here's a few more ways to control the DJ View...



You can start the beat kicking by choosing the Start menu item in the "DJ Control" menu.

You use the Stop button to shut down the beat generation.



Notice Stop is disabled until you start the beat.

Notice Start is disabled after the beat has started.

All user actions are sent to the controller.

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.

The controller takes input from the user and figures out how to translate that into requests on the model.



Controller

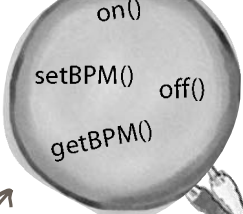
Let's not forget about the model underneath it all...

You can't see the **model**, but you can hear it. The model sits underneath everything else, managing the beat and driving the speakers with MIDI.

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.

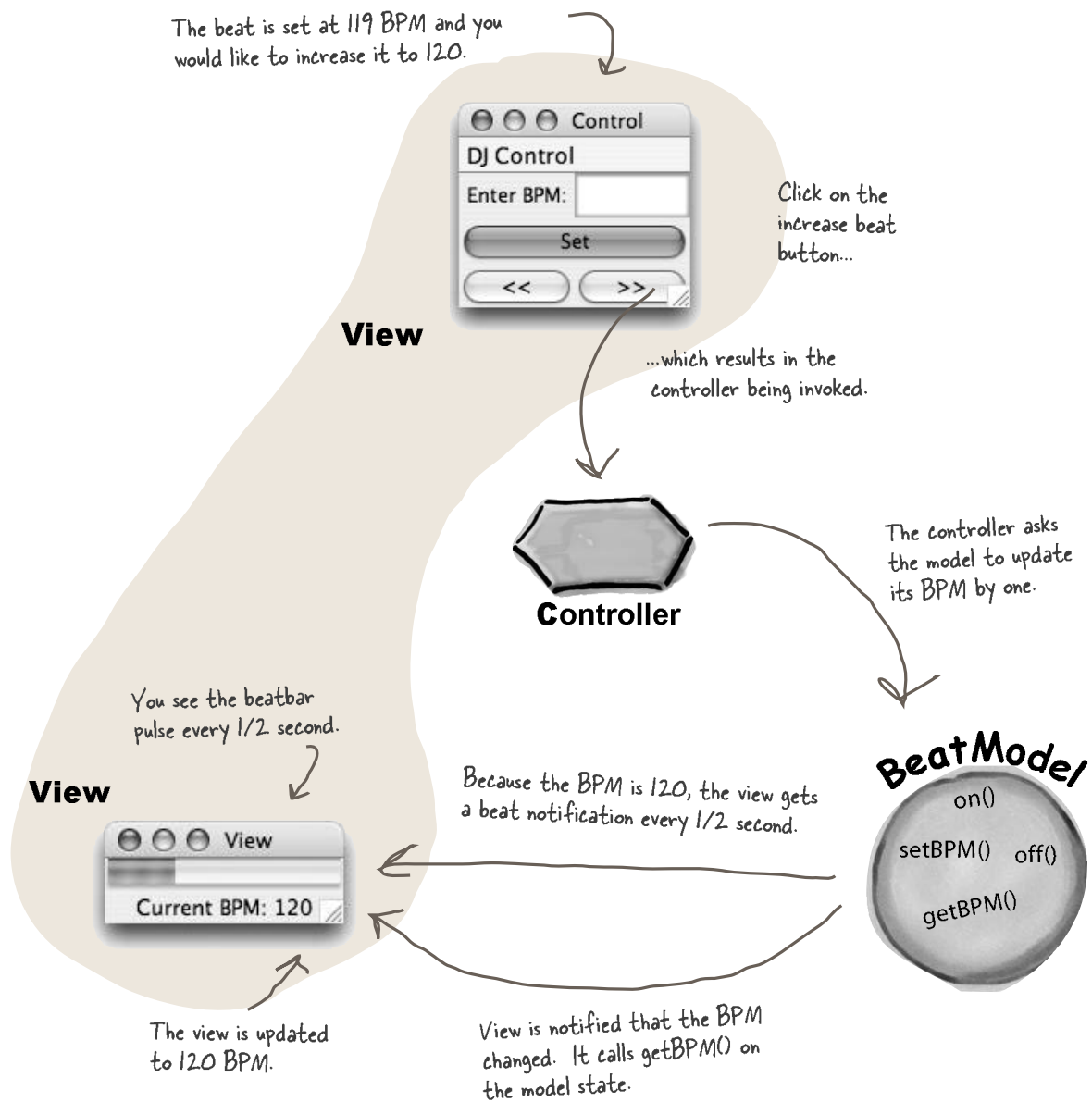
BeatModel



you are here ▶ 535

the *dj model, view and controller*

Putting the pieces together

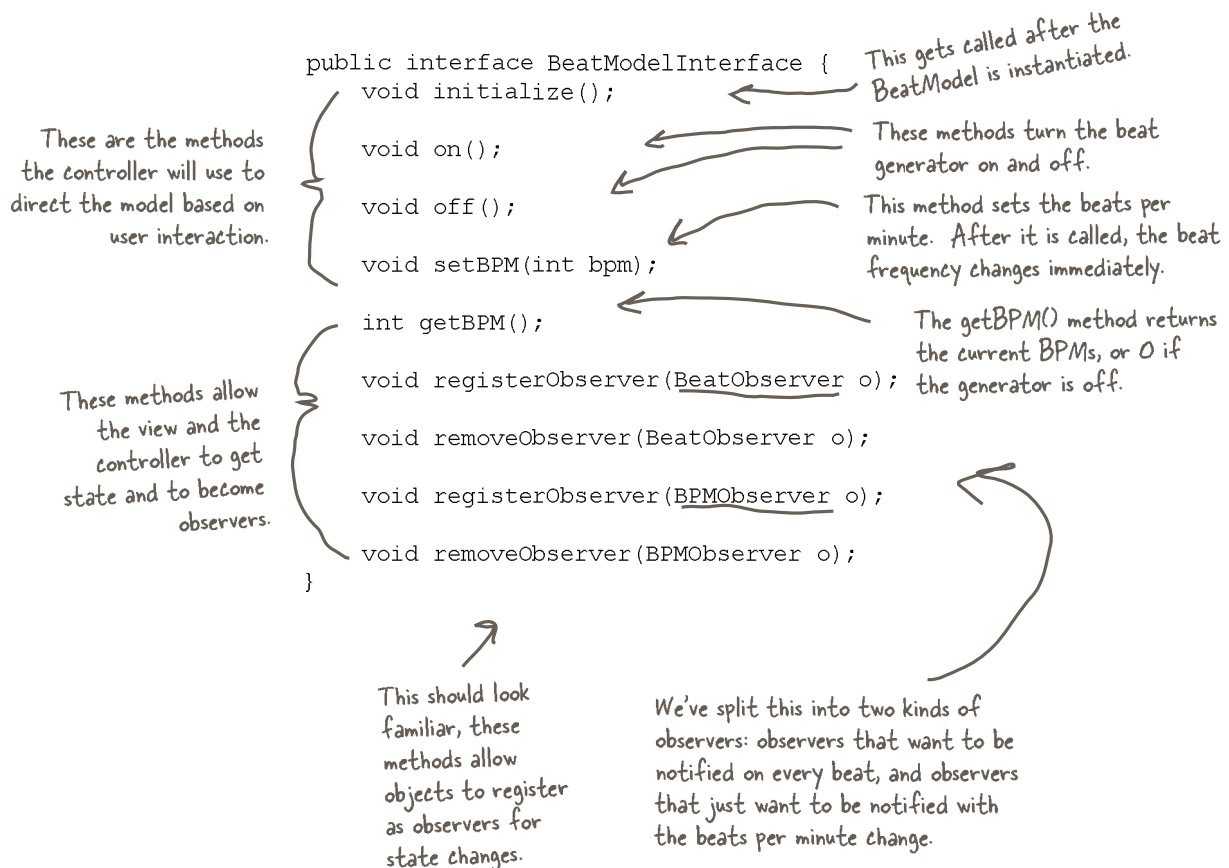




Building the pieces

Okay, you know the model is responsible for maintaining all the data, state and any application logic. So what's the BeatModel got in it? Its main job is managing the beat, so it has state that maintains the current beats per minute and lots of code that generates MIDI events to create the beat that we hear. It also exposes an interface that lets the controller manipulate the beat and lets the view and controller obtain the model's state. Also, don't forget that the model uses the Observer Pattern, so we also need some methods to let objects register as observers and send out notifications.

Let's check out the BeatModelInterface before looking at the implementation:



the beat model

Now let's have a look at the concrete BeatModel class:

We implement the BeatModelInterface. This is needed for the MIDI code.

```
public class BeatModel implements BeatModelInterface, MetaEventListener {
    Sequencer sequencer;
    ArrayList beatObservers = new ArrayList();
    ArrayList bpmObservers = new ArrayList();
    int bpm = 90;
    // other instance variables here

    public void initialize() {
        setUpMidi();
        buildTrackAndStart();
    }

    public void on() {
        sequencer.start();
        setBPM(90);
    }

    public void off() {
        setBPM(0);
        sequencer.stop();
    }

    public void setBPM(int bpm) {
        this.bpm = bpm;
        sequencer.setTempoInBPM(getBPM());
        notifyBPMObservers();
    }

    public int getBPM() {
        return bpm;
    }

    void beatEvent() {
        notifyBeatObservers();
    }

    // Code to register and notify observers
    // Lots of MIDI code to handle the beat
}
```

The sequencer is the object that knows how to generate real beats (that you can hear!).

These ArrayLists hold the two kinds of observers (Beat and BPM observers).

The bpm instance variable holds the frequency of beats – by default, 90 BPM.

This method does setup on the sequencer and sets up the beat tracks for us.

The on() method starts the sequencer and sets the BPMs to the default: 90 BPM.

And off() shuts it down by setting BPMs to 0 and stopping the sequencer.

The setBPM() method is the way the controller manipulates the beat. It does three things:

- (1) Sets the bpm instance variable
- (2) Asks the sequencer to change its BPMs.
- (3) Notifies all BPM Observers that the BPM has changed.

The getBPM() method just returns the bpm instance variable, which indicates the current beats per minute.

The beatEvent() method, which is not in the BeatModelInterface, is called by the MIDI code whenever a new beat starts. This method notifies all BeatObservers that a new beat has just occurred.



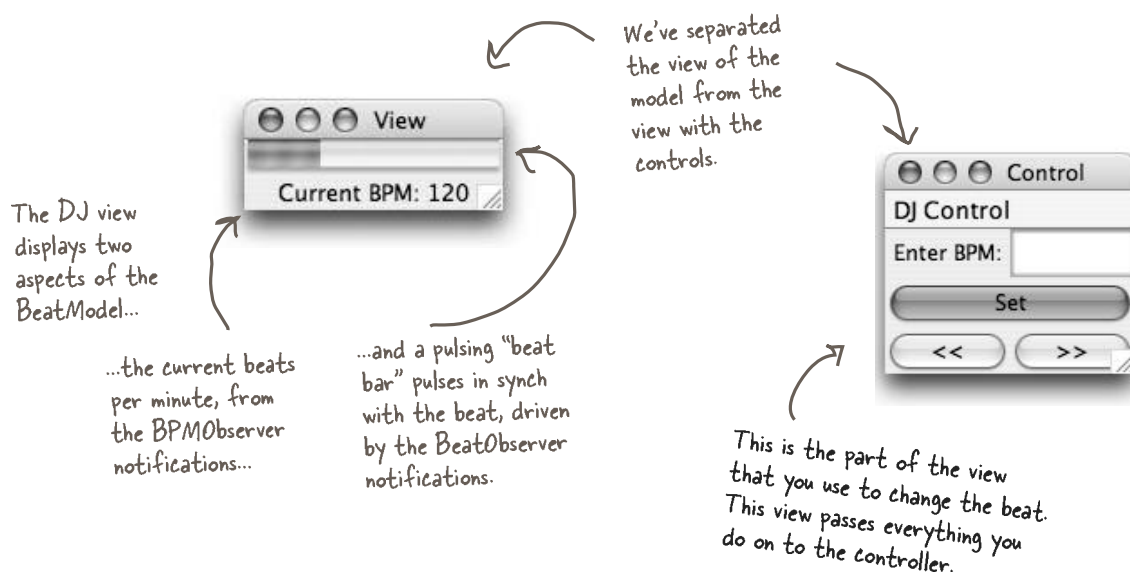
Ready-bake Code

This model uses Java's MIDI support to generate beats. You can check out the complete implementation of all the DJ classes in the Java source files available on the headfirstlabs.com site, or look at the code at the end of the chapter.

The View

Now the fun starts; we get to hook up a view and visualize the BeatModel!

The first thing to notice about the view is that we've implemented it so that it is displayed in two separate windows. One window contains the current BPM and the pulse; the other contains the interface controls. Why? We wanted to emphasize the difference between the interface that contains the view of the model and the rest of the interface that contains the set of user controls. Let's take a closer look at the two parts of the view:



BRAIN POWER

Our BeatModel makes no assumptions about the view. The model is implemented using the Observer Pattern, so it just notifies any view registered as an observer when its state changes. The view uses the model's API to get access to the state. We've implemented one type of view, can you think of other views that could make use of the notifications and state in the BeatModel?

A lightshow that is based on the real-time beat.

A textual view that displays a music genre based on the BPM (ambient, downbeat, techno, etc.).

the *dj* view

Implementing the View

The two parts of the view – the view of the model, and the view with the user interface controls – are displayed in two windows, but live together in one Java class. We'll first show you just the code that creates the view of the model, which displays the current BPM and the beat bar. Then we'll come back on the next page and show you just the code that creates the user interface controls, which displays the BPM text entry field, and the buttons.



Watch it!

The code on these two pages is just an outline!

What we've done here is split ONE class into TWO, showing you one part of the view on this page, and the other part on the next page. All this code is really in ONE class - DJView.java. It's all listed at the back of the chapter.

DJView is an observer for both real-time beats and BPM changes.

```
public class DJView implements ActionListener, BeatObserver, BPMObserver {
    BeatModelInterface model;
    ControllerInterface controller;
    JFrame viewFrame;
    JPanel viewPanel;
    BeatBar beatBar;
    JLabel bpmOutputLabel;
}
```

The view holds a reference to both the model and the controller. The controller is only used by the control interface, which we'll go over in a sec...

Here, we create a few components for the display.

```
public DJView(ControllerInterface controller, BeatModelInterface model) {
    this.controller = controller;
    this.model = model;
    model.registerObserver((BeatObserver)this);
    model.registerObserver((BPMObserver)this);
}
```

The constructor gets a reference to the controller and the model, and we store references to those in the instance variables.

```
public void createView() {
    // Create all Swing components here
}
```

We also register as a BeatObserver and a BPMObserver of the model.

```
public void updateBPM() {
    int bpm = model.getBPM();
    if (bpm == 0) {
        bpmOutputLabel.setText("offline");
    } else {
        bpmOutputLabel.setText("Current BPM: " + model.getBPM());
    }
}
```

The updateBPM() method is called when a state change occurs in the model. When that happens we update the display with the current BPM. We can get this value by requesting it directly from the model.

```
public void updateBeat() {
    beatBar.setValue(100);
}
```

Likewise, the updateBeat() method is called when the model starts a new beat. When that happens, we need to pulse our "beat bar." We do this by setting it to its maximum value (100) and letting it handle the animation of the pulse.

Implementing the View, continued...

Now, we'll look at the code for the user interface controls part of the view. This view lets you control the model by telling the controller what to do, which in turn, tells the model what to do. Remember, this code is in the same class file as the other view code.

```
public class DJView implements ActionListener, BeatObserver, BPMObserver {
    BeatModelInterface model;
    ControllerInterface controller;
    JLabel bpmLabel;
    JTextField bpmTextField;
    JButton setBPMBButton;
    JButton increaseBPMBButton;
    JButton decreaseBPMBButton;
    JMenuBar menuBar;
    JMenu menu;
    JMenuItem startMenuItem;
    JMenuItem stopMenuItem;
```



```
public void createControls() {
    // Create all Swing components here
}
```

This method creates all the controls and places them in the interface. It also takes care of the menu. When the stop or start items are chosen, the corresponding methods are called on the controller.

```
public void enableStopMenuItem() {
    stopMenuItem.setEnabled(true);
}
```

```
public void disableStopMenuItem() {
    stopMenuItem.setEnabled(false);
}
```

All these methods allow the start and stop items in the menu to be enabled and disabled. We'll see that the controller uses these to change the interface.

```
public void enableStartMenuItem() {
    startMenuItem.setEnabled(true);
}
```

```
public void disableStartMenuItem() {
    startMenuItem.setEnabled(false);
}
```

This method is called when a button is clicked.

```
public void actionPerformed(ActionEvent event) {
    if (event.getSource() == setBPMBButton) {
        int bpm = Integer.parseInt(bpmTextField.getText());
        controller.setBPM(bpm);
    } else if (event.getSource() == increaseBPMBButton) {
        controller.increaseBPM();
    } else if (event.getSource() == decreaseBPMBButton) {
        controller.decreaseBPM();
    }
}
```

If the Set button is clicked then it is passed on to the controller along with the new bpm.

Likewise, if the increase or decrease buttons are clicked, this information is passed on to the controller.

```
}
```


the dj controller

Now for the Controller

It's time to write the missing piece: the controller. Remember the controller is the strategy that we plug into the view to give it some smarts.

Because we are implementing the Strategy Pattern, we need to start with an interface for any Strategy that might be plugged into the DJ View. We're going to call it `ControllerInterface`.

```
public interface ControllerInterface {
    void start();
    void stop();
    void increaseBPM();
    void decreaseBPM();
    void setBPM(int bpm);
}
```

Here are all the methods the view can call on the controller.

These should look familiar after seeing the model's interface. You can stop and start the beat generation and change the BPM. This interface is "richer" than the `BeatModel` interface because you can adjust the BPMs with `increase` and `decrease`.



Design Puzzle

You've seen that the view and controller together make use of the Strategy Pattern. Can you draw a class diagram of the two that represents this pattern?



And here's the implementation of the controller:

```
public class BeatController implements ControllerInterface {
    BeatModelInterface model;
    DJView view;

    public BeatController(BeatModelInterface model) {
        this.model = model;
        view = new DJView(this, model);
        view.createView();
        view.createControls();
        view.disableStopMenuItem();
        view.enableStartMenuItem();
        model.initialize();
    }

    public void start() {
        model.on();
        view.disableStartMenuItem();
        view.enableStopMenuItem();
    }

    public void stop() {
        model.off();
        view.disableStopMenuItem();
        view.enableStartMenuItem();
    }

    public void increaseBPM() {
        int bpm = model.getBPM();
        model.setBPM(bpm + 1);
    }

    public void decreaseBPM() {
        int bpm = model.getBPM();
        model.setBPM(bpm - 1);
    }

    public void setBPM(int bpm) {
        model.setBPM(bpm);
    }
}
```

The controller implements the ControllerInterface.

The controller is the creamy stuff in the middle of the MVC oreo cookie, so it is the object that gets to hold on to the view and the model and glues it all together.

The controller is passed the model in the constructor and then creates the view.

When you choose Start from the user interface menu, the controller turns the model on and then alters the user interface so that the start menu item is disabled and the stop menu item is enabled.

Likewise, when you choose Stop from the menu, the controller turns the model off and alters the user interface so that the stop menu item is disabled and the start menu item is enabled.

If the increase button is clicked, the controller gets the current BPM from the model, adds one, and then sets a new BPM.

Same thing here, only we subtract one from the current BPM.

Finally, if the user interface is used to set an arbitrary BPM, the controller instructs the model to set its BPM.

NOTE: the controller is making the intelligent decisions for the view. The view just knows how to turn menu items on and off; it doesn't know the situations in which it should disable them.

putting it all together

Putting it all together...

We've got everything we need: a model, a view, and a controller. Now it's time to put them all together into a MVC! We're going to see and hear how well they work together.

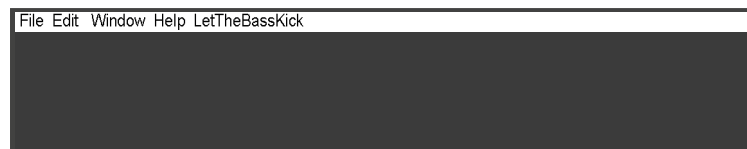
All we need is a little code to get things started; it won't take much:

```
public class DJTestDrive {
    public static void main (String[] args) {
        BeatModelInterface model = new BeatModel();
        ControllerInterface controller = new BeatController(model);
    }
}
```

First create a model...

...then create a controller and pass it the model. Remember, the controller creates the view, so we don't have to do that.

And now for a test run...



Run this...

...and you'll see this.

Things to do

- Start the beat generation with the **Start** menu item; notice the controller disables the item afterwards.
- Use the text entry along with the increase and decrease buttons to change the BPM. Notice how the view display reflects the changes despite the fact that it has no logical link to the controls.
- Notice how the beat bar always keeps up with the beat since it's an observer of the model.
- Put on your favorite song and see if you can beat match the beat by using the increase and decrease controls.
- Stop the generator. Notice how the controller disables the **Stop** menu item and enables the **Start** menu item.

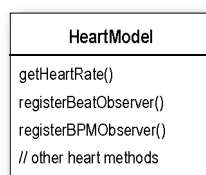


compound patterns

Exploring Strategy

Let's take the Strategy Pattern just a little further to get a better feel for how it is used in MVC. We're going to see another friendly pattern pop up too – a pattern you'll often see hanging around the MVC trio: the Adapter Pattern.

Think for a second about what the DJ View does: it displays a beat rate and a pulse. Does that sound like something else? How about a heartbeat? It just so happens we happen to have a heart monitor class; here's the class diagram:



We've got a method for getting the current heart rate.

And luckily, its developers knew about the Beat and BPM Observer interfaces!



It certainly would be nice to reuse our current view with the HeartModel, but we need a controller that works with this model. Also, the interface of the HeatModel doesn't match what the view expects because it has a `getHeartRate()` method rather than a `getBPM()`. How would you design a set of classes to allow the view to be reused with the new model?



Adapting the Model

For starters, we're going to need to adapt the HeartModel to a BeatModel. If we don't, the view won't be able to work with the model, because the view only knows how to getBPM(), and the equivalent heart model method is getHeartRate(). How are we going to do this? We're going to use the Adapter Pattern, of course! It turns out that this is a common technique when working with the MVC: use an adapter to adapt a model to work with existing controllers and views.

Here's the code to adapt a HeartModel to a BeatModel:

```
public class HeartAdapter implements BeatModelInterface {
    HeartModelInterface heart;

    public HeartAdapter(HeartModelInterface heart) {
        this.heart = heart;
    }
    public void initialize() {}

    public void on() {}
    public void off() {}

    public int getBPM() {
        return heart.getHeartRate();
    }

    public void setBPM(int bpm) {}

    public void registerObserver(BeatObserver o) {
        heart.registerObserver(o);
    }

    public void removeObserver(BeatObserver o) {
        heart.removeObserver(o);
    }

    public void registerObserver(BPMObserver o) {
        heart.registerObserver(o);
    }

    public void removeObserver(BPMObserver o) {
        heart.removeObserver(o);
    }
}
```

We need to implement the target interface, in this case, `BeatModelInterface`.

Here, we store a reference to the heart model.

We don't know what these would do to a heart, but it sounds scary. So we'll just leave them as "no ops."

When `getBPM()` is called, we'll just translate it to a `getHeartRate()` call on the heart model.

We don't want to do this on a heart! Again, let's leave it as a "no op".

Here are our observer methods. We just delegate them to the wrapped heart model.



Now we're ready for a HeartController

With our HeartAdapter in hand we should be ready to create a controller and get the view running with the HeartModel. Talk about reuse!

```
public class HeartController implements ControllerInterface {
    HeartModelInterface model;
    DJView view;

    public HeartController(HeartModelInterface model) {
        this.model = model;
        view = new DJView(this, new HeartAdapter(model));
        view.createView();
        view.createControls();
        view.disableStopMenuItem();
        view.disableStartMenuItem();
    }

    public void start() {}

    public void stop() {}

    public void increaseBPM() {}

    public void decreaseBPM() {}

    public void setBPM(int bpm) {}
}
```

The HeartController implements the ControllerInterface, just like the BeatController did.

Like before, the controller creates the view and gets everything glued together.

There is one change: we are passed a HeartModel, not a BeatModel...

...and we need to wrap that model with an adapter before we hand it to the view.

Finally, the HeartController disables the menu items as they aren't needed.

There's not a lot to do here; after all, we can't really control hearts like we can beat machines.

And that's it! Now it's time for some test code...

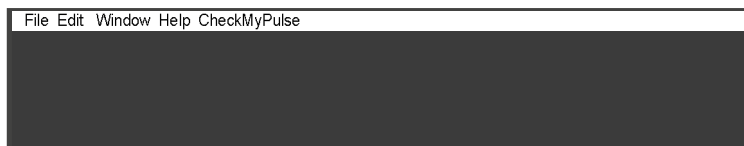
```
public class HeartTestDrive {
    public static void main (String[] args) {
        HeartModel heartModel = new HeartModel();
        ControllerInterface model = new HeartController(heartModel);
    }
}
```

All we need to do is create the controller and pass it a heart monitor.



test the *heart model*

And now for a test run...



Run this...

...and you'll see this.



Nice healthy heart rate.

Things to do

- Notice that the display works great with a heart! The beat bar looks just like a pulse. Because the HeartModel also supports BPM and Beat Observers we can get beat updates just like with the DJ beats.
- As the heartbeat has natural variation, notice the display is updated with the new beats per minute.
- Each time we get a BPM update the adapter is doing its job of translating `getBPM()` calls to `getHeartRate()` calls.
- The Start and Stop menu items are not enabled because the controller disabled them.
- The other buttons still work but have no effect because the controller implements no ops for them. The view could be changed to support the disabling of these items.