

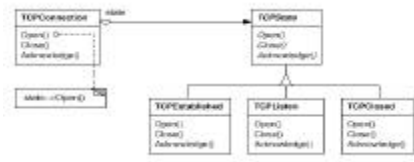
The State and Strategy Patterns

Design Patterns In Java

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The State Pattern

- Intent
 - Allow an object to alter its behavior when its internal state changes. The object will appear to change its class.
- Motivation



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The State Pattern

- Applicability
 - Use the State pattern whenever:
 - An object's behavior depends on its state, and it must change its behavior at run-time depending on that state
 - Operations have large, multipart conditional statements that depend on the object's state. The State pattern puts each branch of the conditional in a separate class.

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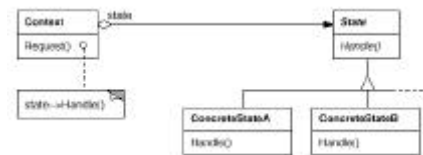
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The State Pattern

- Structure



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The State Pattern

- Consequences
 - Benefits
 - Puts all behavior associated with a state into one object
 - Allows state transition logic to be incorporated into a state object rather than in a monolithic if or switch statement
 - Helps avoid inconsistent states since state changes occur using just the one state object and not several objects or attributes
 - Liabilities
 - Increased number of objects

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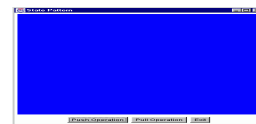
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State Pattern Example 1

- Consider a class that has two methods, push() and pull(), whose behavior changes depending on the state of the object
- To send the push and pull requests to the object, we'll use the following GUI with "Push" and "Pull" buttons:



- The state of the object will be indicated by the color of the canvas in the top part of the GUI
- The states are: black, red, blue and green

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State Pattern Example 1 (Continued)

- First, let's do this without the State pattern:

```
/**
 * Class ContextNoSP has behavior dependent on its state.
 * The push() and pull() methods do different things
 * depending on the state of the object.
 * This class does NOT use the State pattern.
 */
public class ContextNoSP {

    // The state!
    private Color state = null;

    // Creates a new ContextNoSP with the specified state (color).
    public ContextNoSP(Color color) {state = color;}
    // Creates a new ContextNoSP with the default state
    public ContextNoSP() {this(Color.red);}
}
```

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State Pattern Example 1 (Continued)

```
// Returns the state.
public Color getState() {return state;}

// Sets the state.
public void setState(Color state) {this.state = state;}

/**
 * The push() method performs different actions depending
 * on the state of the object. Actually, right now
 * the only action is to make a state transition.
 */
public void push() {
    if (state == Color.red) state = Color.blue;
    else if (state == Color.green) state = Color.black;
    else if (state == Color.black) state = Color.red;
    else if (state == Color.blue) state = Color.green;
}
```

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State Pattern Example 1 (Continued)

```
/**
 * The pull() method performs different actions depending
 * on the state of the object. Actually, right now
 * the only action is to make a state transition.
 */
public void pull() {
    if (state == Color.red) state = Color.green;
    else if (state == Color.green) state = Color.blue;
    else if (state == Color.black) state = Color.green;
    else if (state == Color.blue) state = Color.red;
}
}
```

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State Pattern Example 1 (Continued)

- Here's part of the GUI test program:

```
/**
 * Test program for the ContextNoSP class
 * which does NOT use the State pattern.
 */
public class TestNoSP extends Frame
    implements ActionListener {

    // GUI attributes.
    private Button pushButton = new Button("Push Operation");
    private Button pullButton = new Button("Pull Operation");
    private Button exitButton = new Button("Exit");
    private Canvas canvas = new Canvas();

    // The Context.
    private ContextNoSP context = null;
}
```

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State Pattern Example 1 (Continued)

```
public TestNoSP() {
    super("No State Pattern");
    context = new ContextNoSP();
    setupWindow();
}

private void setupWindow() { // Setup GUI }

// Handle GUI actions.
public void actionPerformed(ActionEvent event) {
    Object src = event.getSource();
    if (src == pushButton) {
        context.push();
        canvas.setBackground(context.getState());
    }
}
```

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State Pattern Example 1 (Continued)

```
else if (src == pullButton) {
    context.pull();
    canvas.setBackground(context.getState());
}
else if (src == exitButton) {
    System.exit(0);
}
}

// Main method.
public static void main(String[] argv) {
    TestNoSP gui = new TestNoSP();
    gui.setVisible(true);
}
}
```

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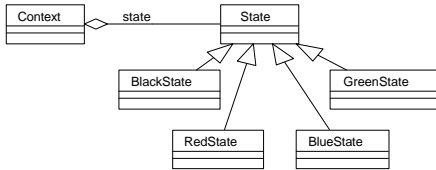
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State Pattern Example 1 (Continued)

- Now let's use the State pattern!
- Here's the class diagram:



State Pattern Example 1 (Continued)

- First, we'll define the abstract State class:

```
/**
 * Abstract class which defines the interface for the
 * behavior of a particular state of the Context.
 */
public abstract class State {
    public abstract void handlePush(Context c);
    public abstract void handlePull(Context c);
    public abstract Color getColor();
}
```

- Next, we'll write concrete State classes for all the different states: RedState, BlackState, BlueState and GreenState

State Pattern Example 1 (Continued)

- For example, here's the BlackState class:

```
public class BlackState extends State {
    // Next state for the Black state:
    // On a push(), go to "red"
    // On a pull(), go to "green"

    public void handlePush(Context c) {
        c.setState(new RedState());
    }

    public void handlePull(Context c) {
        c.setState(new GreenState());
    }

    public Color getColor() {return (Color.black);}
}
```

State Pattern Example 1 (Continued)

- And, here's the new Context class that uses the State pattern and the State classes:

```
/**
 * Class Context has behavior dependent on its state.
 * This class uses the State pattern.
 * Now when we get a pull() or push() request, we
 * delegate the behavior to our contained state object!
 */
public class Context {

    // The contained state.
    private State state = null; // State attribute

    // Creates a new Context with the specified state.
    public Context(State state) {this.state = state;}
}
```

State Pattern Example 1 (Continued)

```
// Creates a new Context with the default state.
public Context() {this(new RedState());}

// Returns the state.
public State getState() {return state;}

// Sets the state.
public void setState(State state) {this.state = state;}
```

State Pattern Example 1 (Continued)

```
/**
 * The push() method performs different actions depending
 * on the state of the object. Using the State pattern,
 * we delegate this behavior to our contained state object.
 */
public void push() {state.handlePush(this);}

/**
 * The pull() method performs different actions depending
 * on the state of the object. Using the State pattern,
 * we delegate this behavior to our contained state object.
 */
public void pull() {state.handlePull(this);}
}
```

The State Pattern

- Implementation Issues
 - Who defines the state transitions?
 - The Context class => ok for simple situations
 - The ConcreteState classes => generally more flexible, but causes implementation dependencies between the ConcreteState classes
 - Example 1 has the ConcreteState classes define the state transitions
 - When are the ConcreteState objects created?
 - Create ConcreteState objects as needed
 - Create all ConcreteState objects once and have the Context object keep references to them
 - Example 1 creates them as needed
 - Can't we just use a state-transition table for all this?
 - Harder to understand
 - Difficult to add other actions and behavior

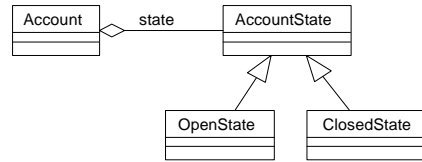
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State Pattern Example 2

- Situation: A bank account can change from an open account to a closed account and back to an open account again. The behavior of the two types of accounts is different.
- Solution: Use the State pattern!



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State Pattern Example 3 - SPOP

- This example comes from Roger Whitney, San Diego State University
- Consider a simplified version of the Post Office Protocol used to download e-mail from a mail server
- Simple POP (SPOP) supports the following command:
 - USER username
 - The USER command with a username must be the first command issued
 - PASS password
 - The PASS command with a password or the QUIT command must come after USER. If the username and password are valid, then the user can use other commands.
 - LIST <message number>
 - The LIST command returns the size of all messages in the mail box. If the optional message number is specified, then it returns the size of that message.

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State Pattern Example 3 - SPOP (Continued)

- RETR <message number>
 - The RETR command retrieves all message in the mail box. If the optional message number is specified, then it retrieves that message.
- QUIT
 - The QUIT command updates the mail box to reflect transactions taken, then logs the user out.

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State Pattern Example 3 - SPOP (Continued)

- Here's a version of an SPop class without using the State pattern:

```
public class SPop {
    static final int QUIT = 1;
    static final int HAVE_USER_NAME = 2;
    static final int START = 3;
    static final int AUTHORIZED = 4;
    private int state = START;
    String userName;
    String password;
}
```

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State Pattern Example 3 - SPOP (Continued)

```
public void user(String userName) {
    switch (state) {
        case START: {
            this.userName = userName;
            state = HAVE_USER_NAME;
            break;
        }
        default: { // Invalid command
            sendErrorMessageOrWhatever();
            endLastSessionWithoutUpdate();
            userName = null;
            password = null;
            state = START;
        }
    }
}
```

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State Pattern Example 3 - SPOP (Continued)

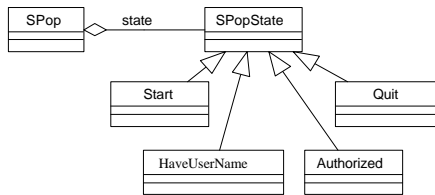
```
public void pass(String password) {
    switch (state) {
        case HAVE_USER_NAME: {
            this.password = password;
            if (validateUser())
                state = AUTHORIZED;
            else {
                sendErrorMessageOrWhatever();
                userName = null;
                password = null;
                state = START;
            }
        }
    }
}
```

State Pattern Example 3 - SPOP (Continued)

```
default: { // Invalid command
    sendErrorMessageOrWhatever();
    endLastSessionWithoutUpdate();
    state = START;
}
}
}
...
}
```

State Pattern Example 3 - SPOP (Continued)

- Now let's use the State pattern!
- Here's the class diagram:



State Pattern Example 3 - SPOP (Continued)

- First, we'll define the SPopState class. Notice that this class is a concrete class that defines default actions.

```
public class SPopState {
    public SPopState user(String userName) {default action here}
    public SPopState pass(String password) {default action here}
    public SPopState list(int messageNumber) {default action here}
    public SPopState retr(int messageNumber) {default action here}
    public SPopState quit() {default action here}
}
```

State Pattern Example 3 - SPOP (Continued)

- Here's the Start class:

```
public class Start extends SPopState {
    public SPopState user(String userName) {
        return new HaveUserName(userName);
    }
}
```

State Pattern Example 3 - SPOP (Continued)

- Here's the HaveUserName class:

```
public class HaveUserName extends SPopState {
    String userName;
    public HaveUserName(String userName) {
        this.userName = userName;
    }
    public SPopState pass(String password) {
        if (validateUser(userName, password))
            return new Authorized(userName);
        else
            return new Start();
    }
}
```

State Pattern Example 3 - SPOP (Continued)

- Finally, here is the SPop class that uses these state classes:

```
public class SPop {
    private SPopState state = new Start();

    public void user(String userName) {
        state = state.user(userName);
    }

    public void pass(String password) {
        state = state.pass(password);
    }

    public void list(int messageNumber) {
        state = state.list(messageNumber);
    }
    ...
}
```

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State Pattern Example 3 - SPOP (Continued)

- Note, that in this example, the state classes specify the next state
- We could have the SPop class itself determine the state transition (the state classes now return true or false):

```
public class SPop {
    private SPopState state = new Start();
    public void user(String userName) {
        state.user(userName);
        state = new HaveUserName(userName);
    }
    public void pass(String password) {
        if (state.pass(password))
            state = new Authorized();
        else
            state = new Start();
    }
}
```

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State Pattern Example 3 - SPOP (Continued)

- Multiple instances of SPop could share state objects if the state objects have no required instance variables or the state objects store their instance variables elsewhere
- Such sharing of objects is an example of the Flyweight Pattern
- How can the state object store its state elsewhere?
 - Have the Context store this data and pass it to the state object (a push model)
 - Have the Context store this data and have the state object retrieve it when needed (a pull model)

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State Pattern Example 3 - SPOP (Continued)

- Here's an example of the Context storing the state and passing it to the state objects:

```
public class SPop {
    private SPopState state = new Start();
    String userName;
    String password;

    public void user(String newName) {
        this.userName = newName;
        state.user(newName);
    }

    public void pass(String password) {
        state.pass(userName, password);
    }
    ...
}
```

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State Pattern Example 3 - SPOP (Continued)

- Here the Context stores the state and the state objects retrieve it:

```
public class SPop {
    private SPopState state = new Start();
    String userName;
    String password;

    public String getUserName() {return userName;}

    public String getPassword() {return password;}

    public void user(String newName) {
        this.userName = newName ;
        state.user(this);
    }
    ...
}
```

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State Pattern Example 3 - SPOP (Continued)

- And here is how the HaveUserName state object retrieves the state in its user() method:

```
public class HaveUserName extends SPopState {

    public SPopState user(SPop mailServer) {
        String userName = mailServer.getUserName();
        ...
    }
    ...
}
```

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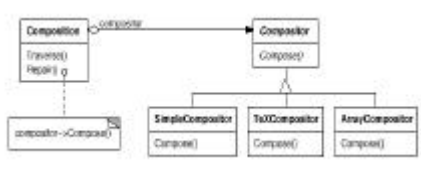
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The Strategy Pattern

- Intent
 - Define a family of algorithms, encapsulate each one, and make them interchangeable. Strategy lets the algorithm vary independently from clients that use it.
- Motivation



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The Strategy Pattern

- Applicability
 - Use the Strategy pattern whenever:
 - Many related classes differ only in their behavior
 - You need different variants of an algorithm
 - An algorithm uses data that clients shouldn't know about. Use the Strategy pattern to avoid exposing complex, algorithm-specific data structures.
 - A class defines many behaviors, and these appear as multiple conditional statements in its operations. Instead of many conditionals, move related conditional branches into their own Strategy class.

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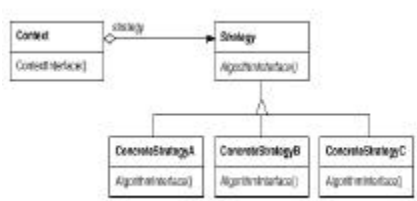
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The Strategy Pattern

- Structure



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The Strategy Pattern

- Consequences
 - Benefits
 - Provides an alternative to subclassing the Context class to get a variety of algorithms or behaviors
 - Eliminates large conditional statements
 - Provides a choice of implementations for the same behavior
 - Liabilities
 - Increases the number of objects
 - All algorithms must use the same Strategy interface

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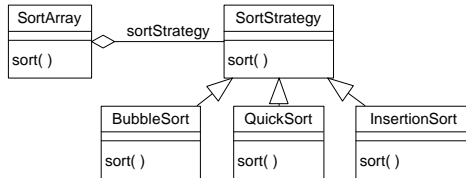
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Strategy Pattern Example 1

- Situation: A class wants to decide at run-time what algorithm it should use to sort an array. Many different sort algorithms are already available.
- Solution: Encapsulate the different sort algorithms using the Strategy pattern!



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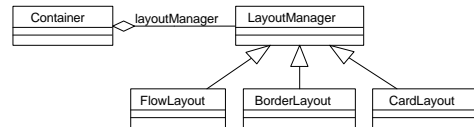
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Strategy Pattern Example 2

- Situation: A GUI container object wants to decide at run-time what strategy it should use to layout the GUI components it contains. Many different layout strategies are already available.
- Solution: Encapsulate the different layout strategies using the Strategy pattern!
- Hey! This is what the Java AWT does with its LayoutManagers!



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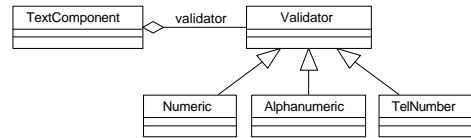
Strategy Pattern Example 2 (Continued)

- Some client code:

```
Frame f = new Frame();  
f.setLayout(new FlowLayout());  
f.add(new Button("Press"));
```

Strategy Pattern Example 3

- Situation: A GUI text component object wants to decide at run-time what strategy it should use to validate user input. Many different validation strategies are possible: numeric fields, alphanumeric fields, telephone-number fields, etc.
- Solution: Encapsulate the different input validation strategies using the Strategy pattern!



Strategy Pattern Example 3 (Continued)

- This is the technique used by the Java Swing GUI text components. Every text component has a reference to a document model which provides the required user input validation strategy.

The Null Object Pattern

- Sometimes the Context may not want to use the strategy provided by its contained Strategy object. That is, the Context wants a “do-nothing” strategy.
- One way to do this is to have the Context assign a null reference to its contained Strategy object. In this case, the Context must always check for this null value:

```
if (strategy != null)  
    strategy.doOperation();
```

The Null Object Pattern

- Another way to accomplish this is to actually have a “do-nothing” strategy class which implements all the required operations of a Strategy object, but these operations do nothing. Now clients do not have to distinguish between strategy objects which actually do something useful and those that do nothing.
- Using a “do-nothing” object for this purpose is known as the *Null Object Pattern*

The Strategy Pattern

- Note the similarities between the State and Strategy patterns! The difference is one of intent.
 - A State object encapsulates a state-dependent behavior (and possibly state transitions)
 - A Strategy object encapsulates an algorithm
- And they are both examples of Composition with Delegation!