

Tecniche di Progettazione: Design Patterns

GoF: State

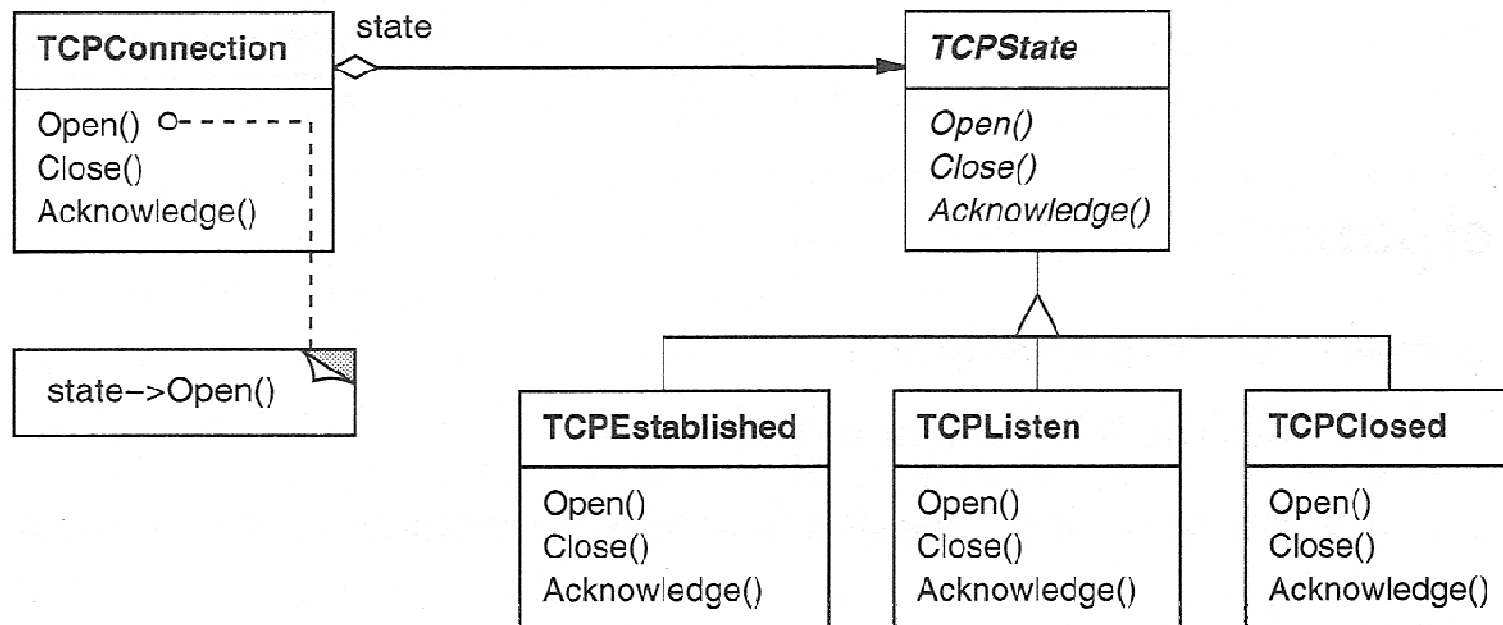
State

- ▶ **Behavioral Pattern**
- ▶ **Intent**
 - ▶ Allow an object to alter its behavior when its internal state changes. The object will appear to change its class
- ▶ **Example**
 - ▶ TCP Connection responds differently to clients based on state
 - ▶ Established
 - ▶ Listening
 - ▶ Closed



Example Structure

- ▶ TCP State is abstract and defines interface
- ▶ Each subclass of TCPState represents a state

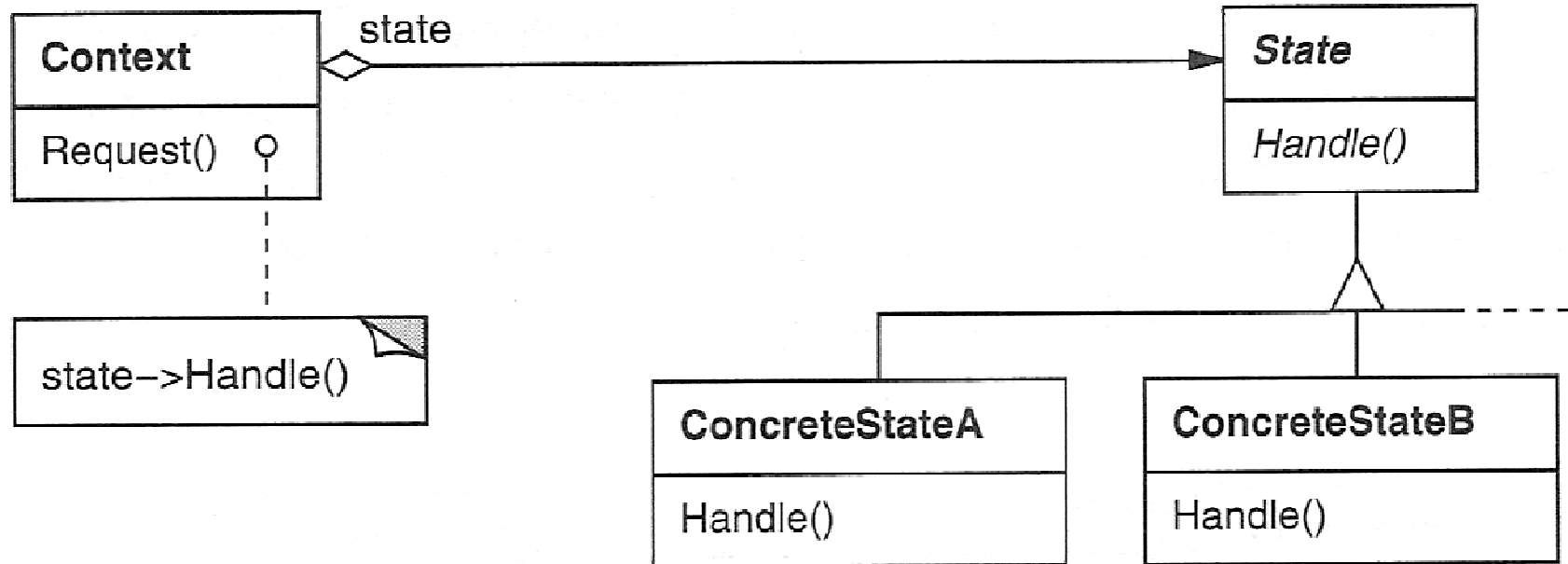


Applicability

- ▶ Use the state pattern in either of the following cases:
 - ▶ 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.



Structure



Participants

- ▶ **Context (TCPConnection)**
 - ▶ Defines the interface of interest to clients
 - ▶ Maintains an instance of a ConcreteState subclass that defines the current state.
- ▶ **State (TCPState)**
 - ▶ Defines an interface for encapsulating the behavior associated with a particular state of the Context
- ▶ **ConcreteState subclasses(TCPEstablished, TCPListen, TCPClosed)**
 - ▶ Each subclass implements a behavior associated with a state of the Context.



Consequences

- ▶ Localizes state-specific behavior and partitions behavior for different states
 - ▶ All state specific behavior is stored in one class
 - ▶ Alternative is giant case statements ☹️
 - ▶ Can produce a large number of classes, but is better than the alternative
- ▶ Makes state Transitions explicit
 - ▶ Current state is stored in one location
- ▶ State objects can be shared
 - ▶ When state objects have no instance variables



Implementation

- ▶ **Who defines the state transitions?**
 - ▶ Can be done by Context
 - ▶ Can be by State Objects
- ▶ **A table-based Alternative**
 - ▶ State Pattern vs. table-driven approach
 - ▶ State pattern models state specific behavior
 - ▶ Table-Driven approach focuses on defining state transitions



Implementation

- ▶ **Creating and destroying State objects**
 - ▶ Create State objects only when they are needed and destroy them afterwards
 - ▶ States changes are infrequent
 - ▶ Pay at use
 - ▶ Create State objects ahead of time and never destroy them
 - ▶ State changes are frequent
 - ▶ Pay upfront



State Pattern Example 1

- ▶ Consider a class with two methods, push() and pull(), whose behavior changes depending on the object state
- ▶ 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

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);}
}
```

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;
}
```

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;
```

```
}
```

```
}
```

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;
```

State Pattern Example 1 (Continued)

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

private void setupWindow() { // Setup GUI }

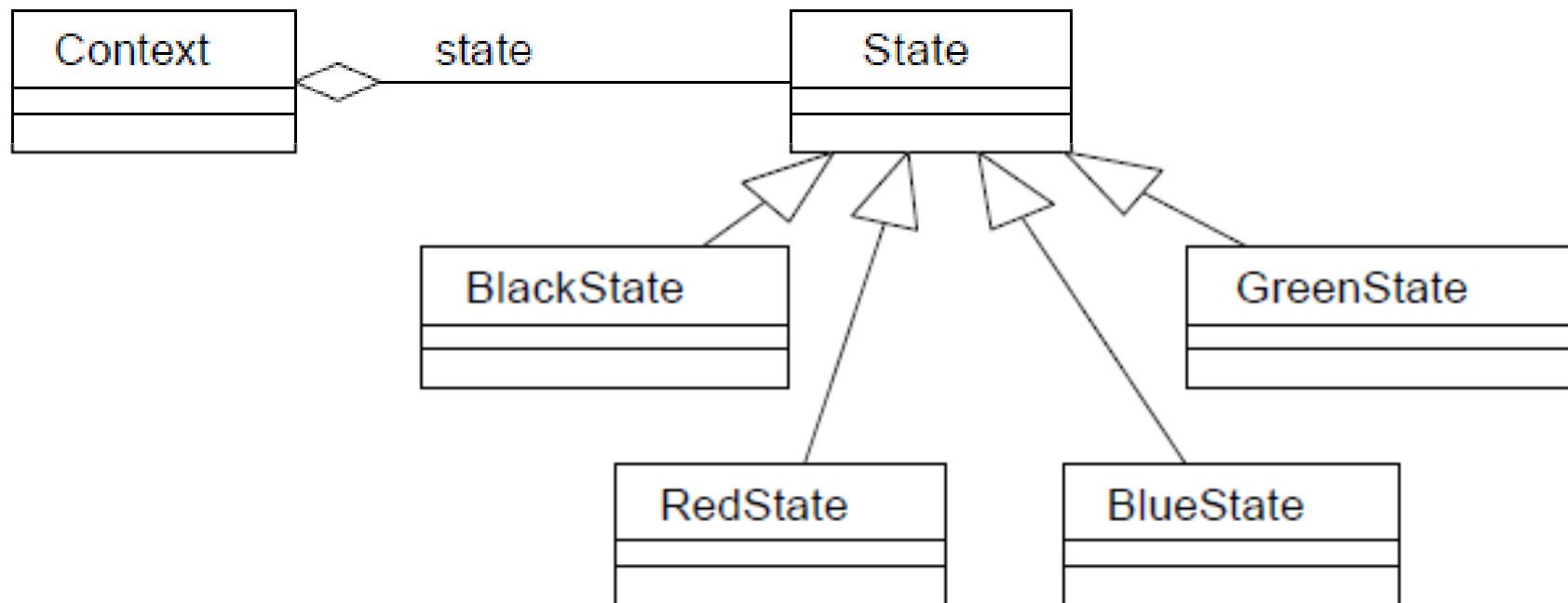
// Handle GUI actions.
public void actionPerformed(ActionEvent event) {
    Object src = event.getSource();
    if (src == pushButton) {
        context.push();
        canvas.setBackground(context.getState());
    }
}
```

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);
}
}
```


State Pattern Example 1 (Continued)

► Using State



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.
```

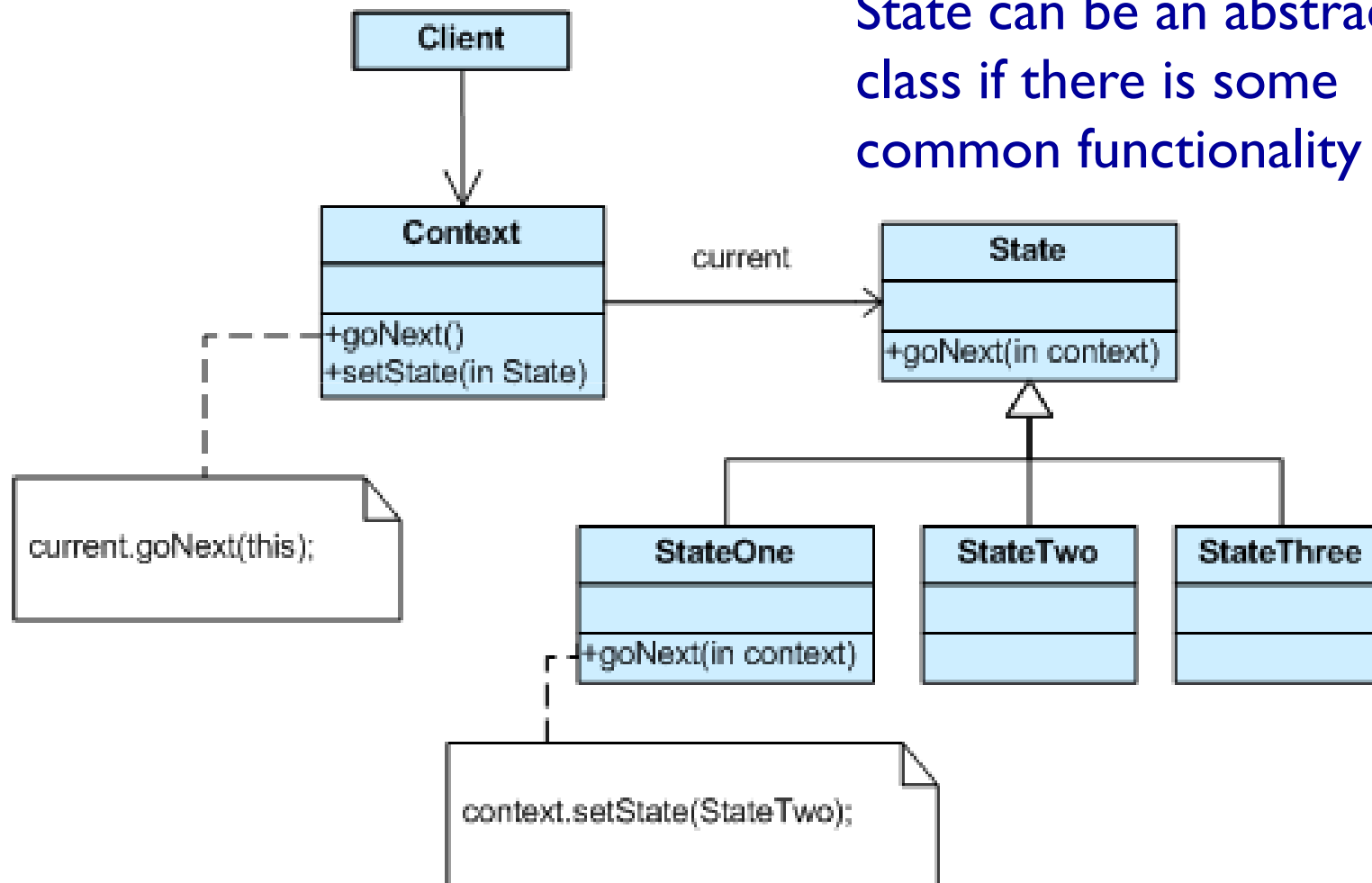
```
*/
```

```
public void pull() {state.handlePull(this);}
}


```

Implementation 1

State can be an abstract class if there is some common functionality



Other Implementations

- ▶ We can let Context to decide the flow of state transition and let the States decide the other actions
 - ▶ Example I has state transition as the only reaction to the commands, but this is not always the case
- ▶ State transition in the state classes is more uniform
 - ▶ But more dependencies between classes.
- ▶ Another approach to writing a State Machine is to use a table-driven approach
 - ▶ Table-driven methods are schemes that allow you to look up information in a table rather than using logic statements (i.e. case, if).
 - ▶ Only for state transition

Check list

1. Identify an existing class, or create a new class, that will serve as the “state machine” from the client’s perspective. That class is the “wrapper” class.
2. Create a State base class that replicates the methods of the state machine interface. Each method takes one additional parameter: an instance of the wrapper class. The State base class specifies any useful “default” behavior.
3. Create a State derived class for each domain state. These derived classes only override the methods they need to override.
4. The wrapper class maintains a “current” State object.
5. All client requests to the wrapper class are simply delegated to the current State object, and the wrapper object’s *this* pointer is passed.
6. The State methods change the “current” state in the wrapper object as appropriate.

State vs Strategy

- ▶ Similarities between the State and Strategy patterns!
- ▶ E.g. they are both examples of Composition with Delegation.
- ▶ The difference is one of intent.
 - ▶ A State object encapsulates a state-dependent behavior (and possibly state transitions)
 - ▶ A Strategy object encapsulates an algorithm
 - ▶ In State a Context object changes state according to well defined state transitions.

