Tecniche di Progettazione: Design Patterns

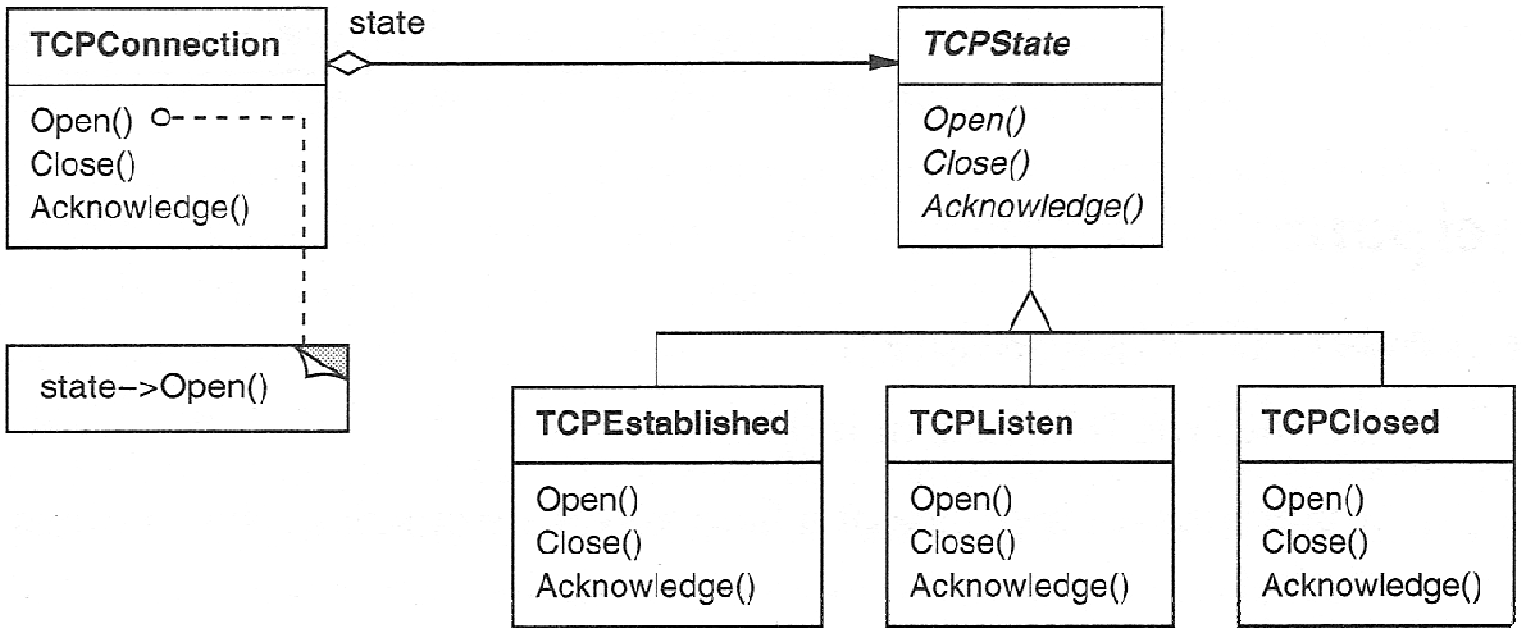
GoF: State

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

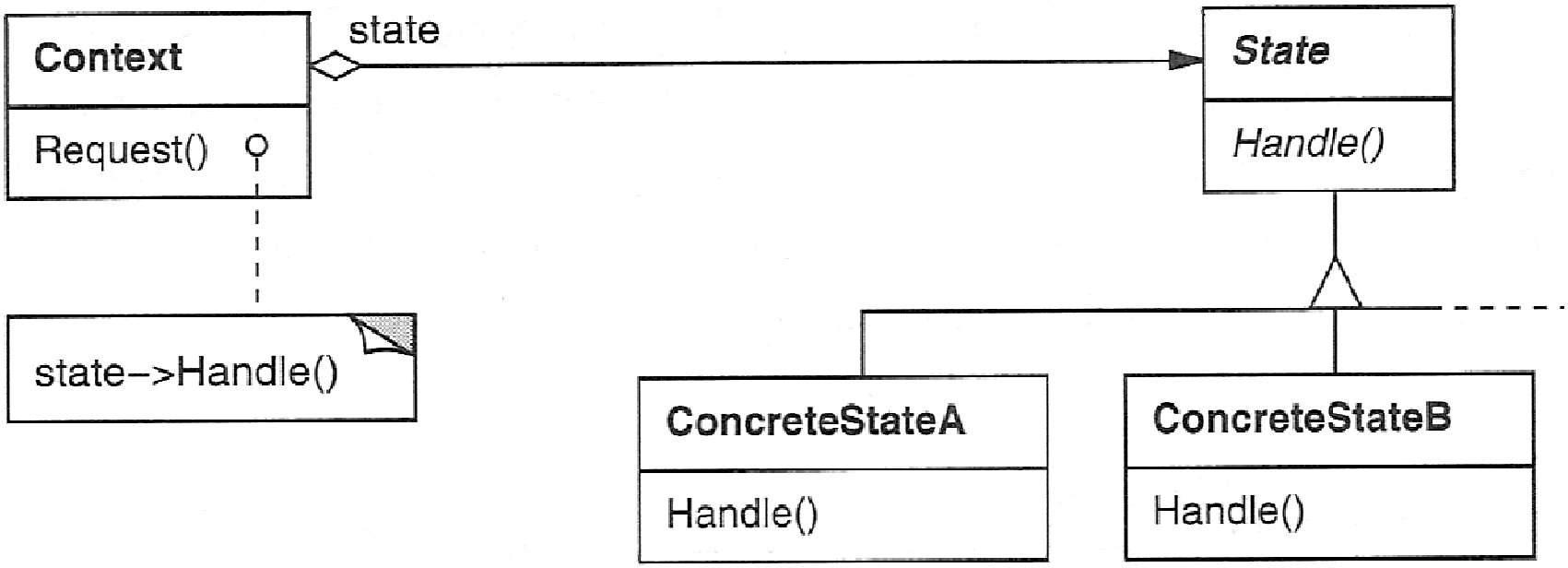
- TCP State is abstract and defines interface
- Each subclass of TCPState represents a state



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


Context
Request()
state
State
Handle()
state->Handle()
ConcreteStateA
Handle()
ConcreteStateB
Handle()

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)

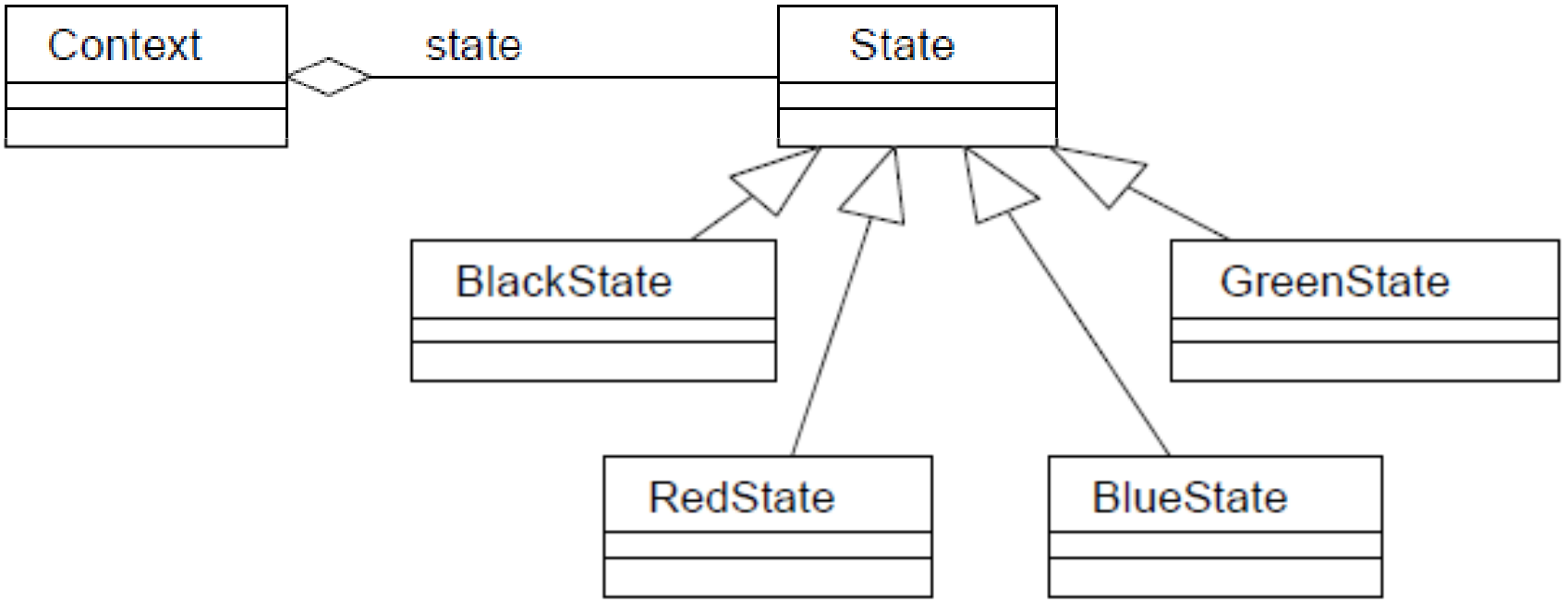
```
public TestNoSP() {
    super("No State Pattern");
    context = new ContextNoSP();
    setupWindow();
}
private void setupWindow() { // Setup GUI }

// 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)

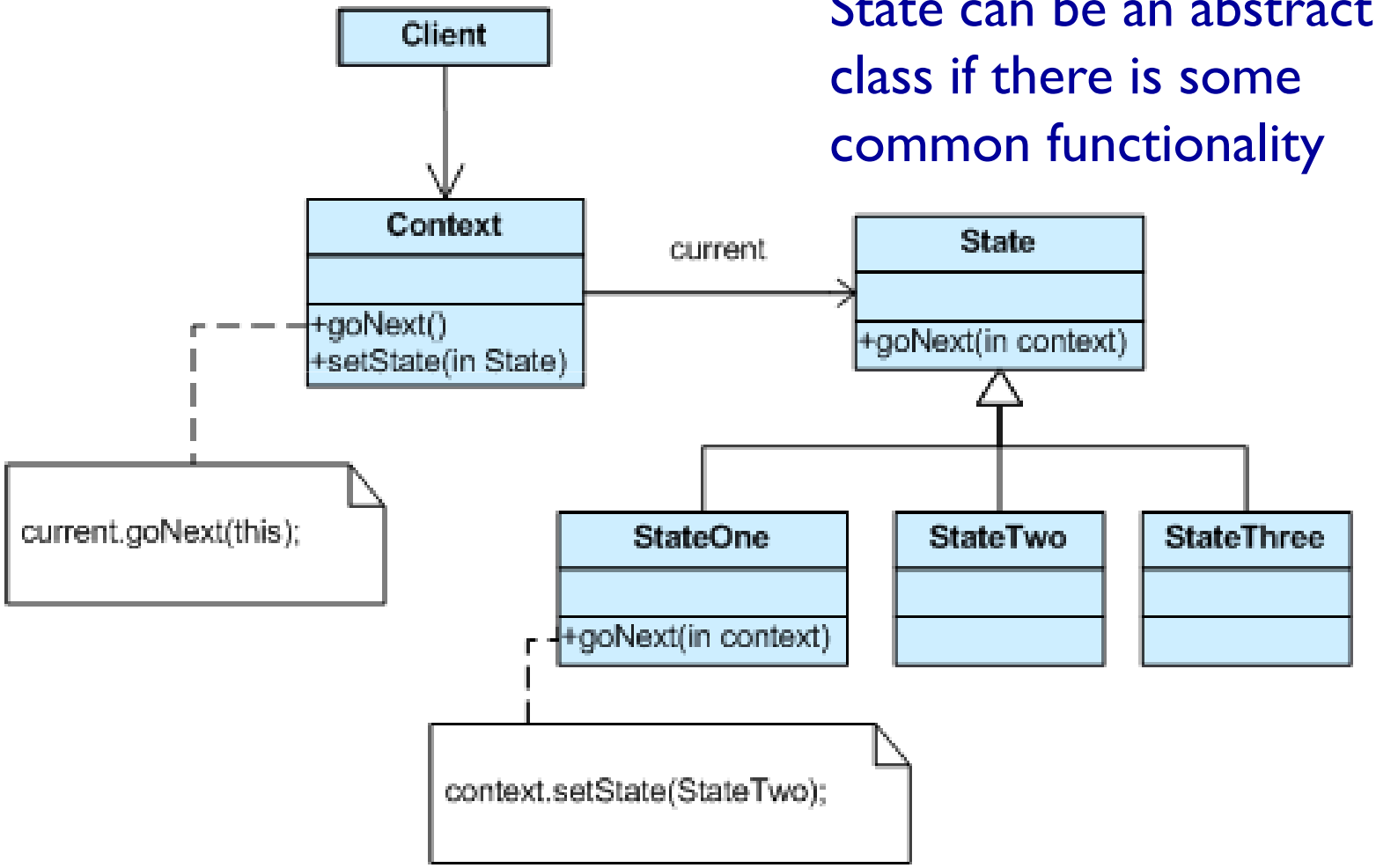
```
    // Creates a new Context with the default state.
public Context() {this(new RedState());}
    // Returns the state.
public State getState() {return state;}
    // Sets the state.
public void setState(State state) {this.state = state;}
```

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 Contex to decide the flow of state transition and let the States decide the other actions
  - Example 1 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 transtion

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.