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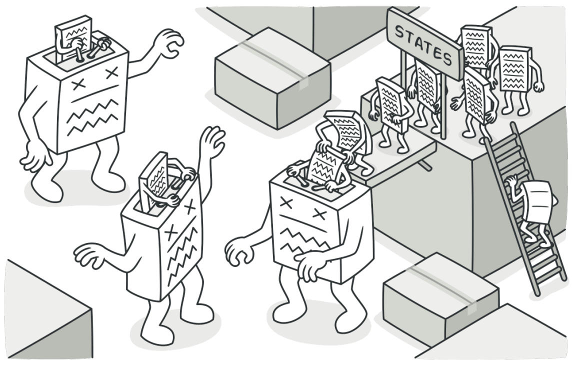
State

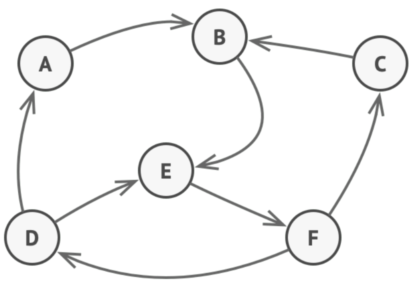
Intent

State is a behavioral design pattern that lets an object alter its behavior when its internal state changes. It appears as if the object changed its class.



Problem

The State pattern is closely related to the concept of a **Finite-State Machine**.



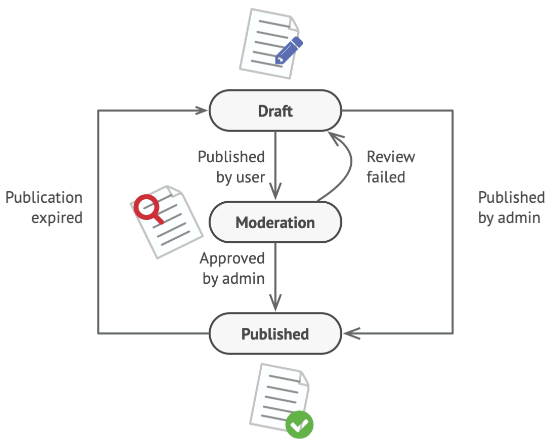
$$\begin{tikzcd}
 & A \arrow[r, bend left] & B \arrow[d, bend left] & C \arrow[l] \\
 & & E \arrow[rd] & \\
 & D \arrow[uu] \arrow[ru] & & F \arrow[ll, bend left] \arrow[uu, bend right]
\end{tikzcd}$$

Finite-State Machine.

The main idea is that, at any given moment, there's a *finite* number of *states* which a program can be in. Within any unique state, the program behaves differently, and the program can be switched from one state to another instantaneously. However, depending on a current state, the program may or may not switch to certain other states. These switching rules, called *transitions*, are also finite and predetermined.

You can also apply this approach to objects. Imagine that we have a `Document` class. A document can be in one of three states: `Draft`, `Moderation` and `Published`. The `publish` method of the document works a little bit differently in each state:

- In `Draft`, it moves the document to moderation.
- In `Moderation`, it makes the document public, but only if the current user is an administrator.
- In `Published`, it doesn't do anything at all.



Possible states and transitions of a document object.

State machines are usually implemented with lots of conditional operators (`if` or `switch`) that select the appropriate behavior depending on the current state of the object. Usually, this "state" is just a set of values of the object's fields. Even if you've never heard about finite-state machines before, you've probably implemented a state at least once. Does the following code structure ring a bell?

```
class Document is
    field state: string
    // ...
    method publish() is
        switch (state)
            "draft":
                state = "moderation"
                break
            "moderation":
                if (currentUser.role == 'admin')
                    state = "published"
                break
            "published":
                // Do nothing.
                break
    // ...
```

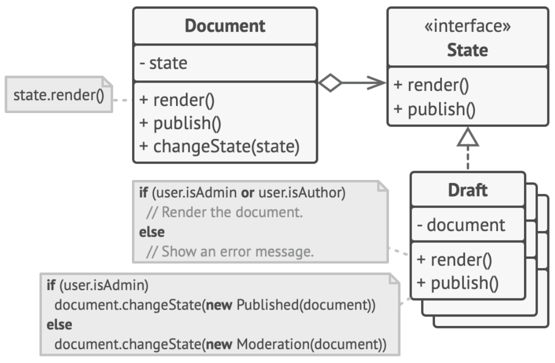
The biggest weakness of a state machine based on conditionals reveals itself once we start adding more and more states and state-dependent behaviors to the `Document` class. Most methods will contain monstrous conditionals that pick the proper behavior of a method according to the current state. Code like this is very difficult to maintain because any change to the transition logic may require changing state conditionals in every method.

The problem tends to get bigger as a project evolves. It's quite difficult to predict all possible states and transitions at the design stage. Hence, a lean state machine built with a limited set of conditionals can grow into a bloated mess over time.

😊 Solution

The State pattern suggests that you create new classes for all possible states of an object and extract all state-specific behaviors into these classes.

Instead of implementing all behaviors on its own, the original object, called *context*, stores a reference to one of the state objects that represents its current state, and delegates all the state-related work to that object.



```
state.render()
```

```
if (user.isAdmin or user.isAuthor)
  // Render the document.
else
  // Show an error message.
```

```
if (user.isAdmin)
  document.changeState(new Published(document))
else
  document.changeState(new Moderation(document))
```

Document delegates the work to a state object.

To transition the context into another state, replace the active state object with another object that represents that new state. This is possible only if all state classes follow the same interface and the context itself works with these objects through that interface.

This structure may look similar to the **Strategy** pattern, but there's one key difference. In the State pattern, the particular states may be aware of each other and initiate transitions from one state to another, whereas strategies almost never know about each other.

🚗 Real-World Analogy

The buttons and switches in your smartphone behave differently depending on the current state of the device:

- When the phone is unlocked, pressing buttons leads to executing various functions.
- When the phone is locked, pressing any button leads to the unlock screen.
- When the phone's charge is low, pressing any button shows

the charging screen.

Structure

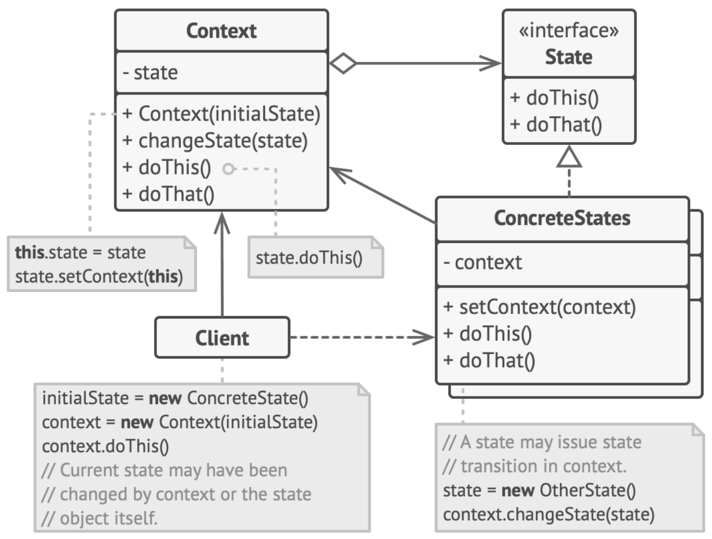
1 **Context** stores a reference to one of the concrete state objects and delegates to it all state-specific work. The context communicates with the state object via the state interface. The context exposes a setter for passing it a new state object.

2 The **State** interface declares the state-specific methods. These methods should make sense for all concrete states because you don't want some of your states to have useless methods that will never be called.

3 **Concrete States** provide thei implementations for the sta specific methods. To avoid duplication of similar code a multiple states, you may pro intermediate abstract classe encapsulate some common behavior.

State objects may store a backreference to the contex object. Through this referen state can fetch any required from the context object, as v initiate state transitions.

4 Both context and concrete s can set the next state of the context and perform the act state transition by replacing state object linked to the co



```
this.state = state
state.setContext(this)
```

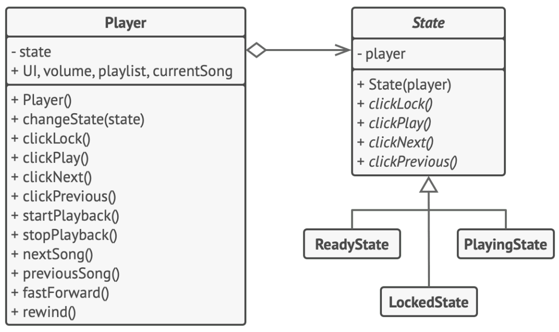
```
state.doThis()
```

```
initialState = new ConcreteState()
context = new Context(initialState)
context.doThis()
// Current state may have been
// changed by context or the state
// object itself.
```

```
// A state may issue state
// transition in context.
state = new OtherState()
context.changeState(state)
```

Pseudocode

In this example, the **State** pattern lets the same controls of the media player behave differently, depending on the current playback state.



Example of changing object behavior with state objects.

The main object of the player is always linked to a state object that performs most of the work for the player. Some actions replace the current state object of the player with another, which changes the way the player reacts to user interactions.

```
// The AudioPlayer class acts as a context. It also maint
// reference to an instance of one of the state classes t
// represents the current state of the audio player.
class AudioPlayer is
    field state: State
    field UI, volume, playlist, currentSong

    constructor AudioPlayer() is
        this.state = new ReadyState(this)

        // Context delegates handling user input to a sta
        // object. Naturally, the outcome depends on what
        // is currently active, since each state can hanc
        // input differently.
        UI = new UserInterface()
        UI.lockButton.onClick(this.clickLock)
        UI.playButton.onClick(this.clickPlay)
        UI.nextButton.onClick(this.clickNext)
        UI.prevButton.onClick(this.clickPrevious)

    // Other objects must be able to switch the audio pla
    // active state.
    method changeState(state: State) is
        this.state = state

    // UI methods delegate execution to the active state.
    method clickLock() is
        state.clickLock()
    method clickPlay() is
        state.clickPlay()
    method clickNext() is
        state.clickNext()
    method clickPrevious() is
        state.clickPrevious()

    // A state may call some service methods on the conte
    method startPlayback() is
        // ...
    method stopPlayback() is
        // ...
    method nextSong() is
        // ...
    method previousSong() is
        // ...
    method fastForward(time) is
        // ...
    method rewind(time) is
        // ...


// The base state class declares methods that all concret
// states should implement and also provides a backrefere
// the context object associated with the state. States c
// the backreference to transition the context to another
abstract class State is
    protected field player: AudioPlayer

    // Context passes itself through the state constructo
    // may help a state fetch some useful context data if
    // needed.
    constructor State(player) is
        this.player = player

    abstract method clickLock()
    abstract method clickPlay()
    abstract method clickNext()
    abstract method clickPrevious()


// Concrete states implement various behaviors associatec
// state of the context.
class LockedState extends State is

    // When you unlock a locked player, it may assume one
    // states.
    method clickLock() is
        if (player.playing)
            player.changeState(new PlayingState(player))
        else
            player.changeState(new ReadyState(player))

    method clickPlay() is
        // Locked, so do nothing.

    method clickNext() is
        // Locked, so do nothing.

    method clickPrevious() is
        // Locked, so do nothing.


// They can also trigger state transitions in the context
class ReadyState extends State is
    method clickLock() is
        player.changeState(new LockedState(player))

    method clickPlay() is
        player.startPlayback()
        player.changeState(new PlayingState(player))

    method clickNext() is
        player.nextSong()

    method clickPrevious() is
        player.previousSong()


class PlayingState extends State is
    method clickLock() is
        player.changeState(new LockedState(player))

    method clickPlay() is
        player.stopPlayback()
        player.changeState(new ReadyState(player))

    method clickNext() is
        if (event.doubleclick)
            player.nextSong()
        else
            player.fastForward(5)

    method clickPrevious() is
        if (event.doubleclick)
            player.previous()
        else
            player.rewind(5)
```

Applicability

Use the State pattern when you have an object that behaves differently depending on its current state, the number of states is enormous, and the state-specific code changes frequently.

The pattern suggests that you extract all state-specific code into a set of distinct classes. As a result, you can add new states or change existing ones independently of each other, reducing the maintenance cost.

Use the pattern when you have a class polluted with massive conditionals that alter how the class behaves

according to the current values of the class's fields.

The State pattern lets you extract branches of these conditionals into methods of corresponding state classes. While doing so, you can also clean temporary fields and helper methods involved in state-specific code out of your main class.

Use State when you have a lot of duplicate code across similar states and transitions of a condition-based state machine.

The State pattern lets you compose hierarchies of state classes and reduce duplication by extracting common code into abstract base classes.

How to Implement

1. Decide what class will act as the context. It could be an existing class which already has the state-dependent code; or a new class, if the state-specific code is distributed across multiple classes.

2. Declare the state interface. Although it may mirror all the methods declared in the context, aim only for those that may contain state-specific behavior.

3. For every actual state, create a class that derives from the state interface. Then go over the methods of the context and extract all code related to that state into your newly created class.

   While moving the code to the state class, you might discover that it depends on private members of the context. There are several workarounds:

   - Make these fields or methods public.
   - Turn the behavior you're extracting into a public method in the context and call it from the state class. This way is ugly but quick, and you can always fix it later.
   - Nest the state classes into the context class, but only if your programming language supports nesting classes.

4. In the context class, add a reference field of the state interface type and a public setter that allows overriding the value of that field.

5. Go over the method of the context again and replace empty state conditionals with calls to corresponding methods of the state object.

6. To switch the state of the context, create an instance of one of the state classes and pass it to the context. You can do this within the context itself, or in various states, or in the client. Wherever this is done, the class becomes dependent on the concrete state class that it instantiates.

Pros and Cons

- ✓ *Single Responsibility Principle*. Organize the code related to particular states into separate classes.
- ✓ *Open/Closed Principle*. Introduce new states without changing existing state classes or the context.
- ✓ Simplify the code of the context by eliminating bulky state machine conditionals.

- ✗ Applying the pattern can be overkill if a state machine has only a few states or rarely changes.

Relations with Other Patterns

- **Bridge**, **State**, **Strategy** (and to some degree **Adapter**) have very similar structures. Indeed, all of these patterns are based on composition, which is delegating work to other objects. However, they all solve different problems. A pattern isn't just a recipe for structuring your code in a specific way. It can also communicate to other developers the problem the pattern solves.

- **State** can be considered as an extension of **Strategy**. Both patterns are based on composition: they change the behavior of the context by delegating some work to helper objects. *Strategy* makes these objects completely independent and unaware of each other. However, *State* doesn't restrict dependencies between concrete states, letting them alter the state of the context at will.

Code Examples

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