State Pattern

Design Patterns

- Approaches to common programming design problems

- There are many design patterns
  - We'll only focus on the state pattern in this course
  - For more patterns, search "The Gang of Four"

- The primary goal of design patterns is to simplify the Design and Maintainability of our programs

State Pattern

- Applies Polymorphism

- Every object contains state and behavior
- We use state variables to change the state of an object and its behavior can depend on this state

- **What if we want to significantly change the behavior of an object?**

State Pattern

- **What if we want to significantly change the behavior of an object?**

- Use if statements?
  - if(condition){someBehavior()}
  - else{completelyDifferentBehavior()}

- This will work, but what about maintainability?

State Pattern

- **What if we want to significantly change the behavior of an object?**

- What if we want many different behaviors
  - if(condition){someBehavior()}
  - else if(otherCondition1){otherBehavior1()}
  - else if(otherCondition2){otherBehavior2()}
  - else if(otherCondition3){otherBehavior3()}
  - else{completelyDifferentBehavior()}
- This would all be in a single method
  - Hard to read
  - Hard to maintain
  - Need to re-test existing functionality each time a condition is added

State Pattern

- Let's try using the **state pattern** as an alternative
- Instead of storing each behavior in the same class, we defer functionality to a state **object**
- Have a state variable containing the current state as an **object**
- Change the state as needed
- Decisions made on type (Polymorphism) not value (Conditionals)
- Modularizes code
  - More, but smaller, pieces of functionality

- Easy to add new features without breaking tested features

State Pattern

- State is represented by an abstract class
  - Defines the methods that can be called (API)
- Extend the state class for each concrete state
  - One class for each possible state
- Each state will have a reference to the object to which it is attached
  - Use this reference to access other state variables
  - Use this reference to change state

State Pattern - Example

- OK cool, but what does all that actually mean?
- Let's use the cool-headed Bruce Banner as an example
  - Bruce is a world-class scientist
  - Bruce can successfully drive a car
  - Bruce is not very helpful in a fight

State Pattern - Example

- However.. Make Bruce angry and he'll become The Incredible Hulk!
  - Smashes cars
  - Great in a fight
  - Out of control!

State Pattern - Example

- One being
- Two significantly different behaviors depending on his current state

State Pattern - Example

- To simulate Bruce in a program, we will create one BruceBanner class containing the behavior in both states
- Bruce Banner can use cars and fight very differently depending on his state
- Defer to a State object to determine how he behaves

State Pattern - Example

- To simulate Bruce in a program, we will create one BruceBanner class containing the behavior in both states
- Bruce Banner can use cars and fight very differently depending on his state
- Defer to a State object to determine how he behaves

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

}
```

State Pattern - Example

- Create State as an abstract class to define all the methods each state must contain (API)
- Extend State for each possible concrete state
- Implement the methods for each state

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

}
```

```
abstract class State(banner: BruceBanner) {

  def makeAngry()

  def calmDown()

  def useCar(car: Car)

  def fight()

}
```

```
class DrBanner(banner: BruceBanner) extends State(banner) {

  override def makeAngry(): Unit = {
    banner.state = new TheHulk(banner)
  }

  override def calmDown(): Unit = {
    println("already calm")
  }

  override def useCar(car: Car): Unit = {
    car.drive(false)
  }

  override def fight(): Unit = {
    println("this won't end well")
  }

}
```

```
class TheHulk(banner: BruceBanner) extends State(banner){

  override def makeAngry(): Unit = {
    println("already angry")
  }

  override def calmDown(): Unit = {
    banner.state = new DrBanner(banner)
  }

  override def useCar(car: Car): Unit = {
    car.smash()
  }

  override def fight(): Unit = {
    println("Hulk Smash!")
  }

}
```

State Pattern - Example

- BruceBanner class stores a variable of type State
  - Don't worry about what concrete type state is
  - Through polymorphism, the methods in State must be implemented and can be called
- Pass each new state a reference to BruceBanner
  - Use the keyword **this**
- Since the reference is passed, each state can access Bruce's state variables, including the state itself

```
abstract class State(banner: BruceBanner) {

  def makeAngry()

  def calmDown()

  def useCar(car: Car)

  def fight()

}
```

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

}
```

State Pattern - Example

- Having access to the state allows each state to replace itself with a new state
- We call this a state transition

```
abstract class State(banner: BruceBanner) {

  def makeAngry()

  def calmDown()

  def useCar(car: Car)

  def fight()

}
```

```
class DrBanner(banner: BruceBanner) extends State(banner) {

  override def makeAngry(): Unit = {
    banner.state = new TheHulk(banner)
  }

  override def calmDown(): Unit = {
    println("already calm")
  }

  override def useCar(car: Car): Unit = {
    car.drive(false)
  }

  override def fight(): Unit = {
    println("this won't end well")
  }

}
```

```
class TheHulk(banner: BruceBanner) extends State(banner){

  override def makeAngry(): Unit = {
    println("already angry")
  }

  override def calmDown(): Unit = {
    banner.state = new DrBanner(banner)
  }

  override def useCar(car: Car): Unit = {
    car.smash()
  }

  override def fight(): Unit = {
    println("Hulk Smash!")
  }

}
```

State Pattern - Example

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

}
```

```
abstract class State(banner: BruceBanner) {

  def makeAngry()

  def calmDown()

  def useCar(car: Car)

  def fight()

}
```

```
class DrBanner(banner: BruceBanner) extends State(banner) {

  override def makeAngry(): Unit = {
    banner.state = new TheHulk(banner)
  }

  override def calmDown(): Unit = {
    println("already calm")
  }

  override def useCar(car: Car): Unit = {
    car.drive(false)
  }

  override def fight(): Unit = {
    println("this won't end well")
  }

}
```

```
class TheHulk(banner: BruceBanner) extends State(banner){

  override def makeAngry(): Unit = {
    println("already angry")
  }

  override def calmDown(): Unit = {
    banner.state = new DrBanner(banner)
  }

  override def useCar(car: Car): Unit = {
    car.smash()
  }

  override def fight(): Unit = {
    println("Hulk Smash!")
  }

}
```

State Pattern - Example

- With two states we could have easily used a single conditional and a boolean flag to store the state
  - Arguably simpler than using the state pattern

- The true power of this pattern comes when we have more states

State Pattern - Example

- Meet Professor Hulk
- Bruce Banner transformed as the Hulk with full control
  - Can drive a car **and** is great in a fight

State Pattern - Example

- To add the new state
  - Create a new class and implement the State methods
  - Add a state transition to enter the new state
- **Did not modify any existing functionality!**

```
class ProfessorHulk(banner: BruceBanner) extends State(banner){

  override def makeAngry(): Unit = {
    println("I'm always angry")
  }

  override def calmDown(): Unit = {
    println("OK")
  }

  override def useCar(car: Car): Unit = {
    car.drive(true)
  }

  override def fight(): Unit = {
    println("Smash carefully")
  }

}
```

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

  def learnControl():Unit = {
    this.state = new ProfessorHulk(this)
  }

}
```

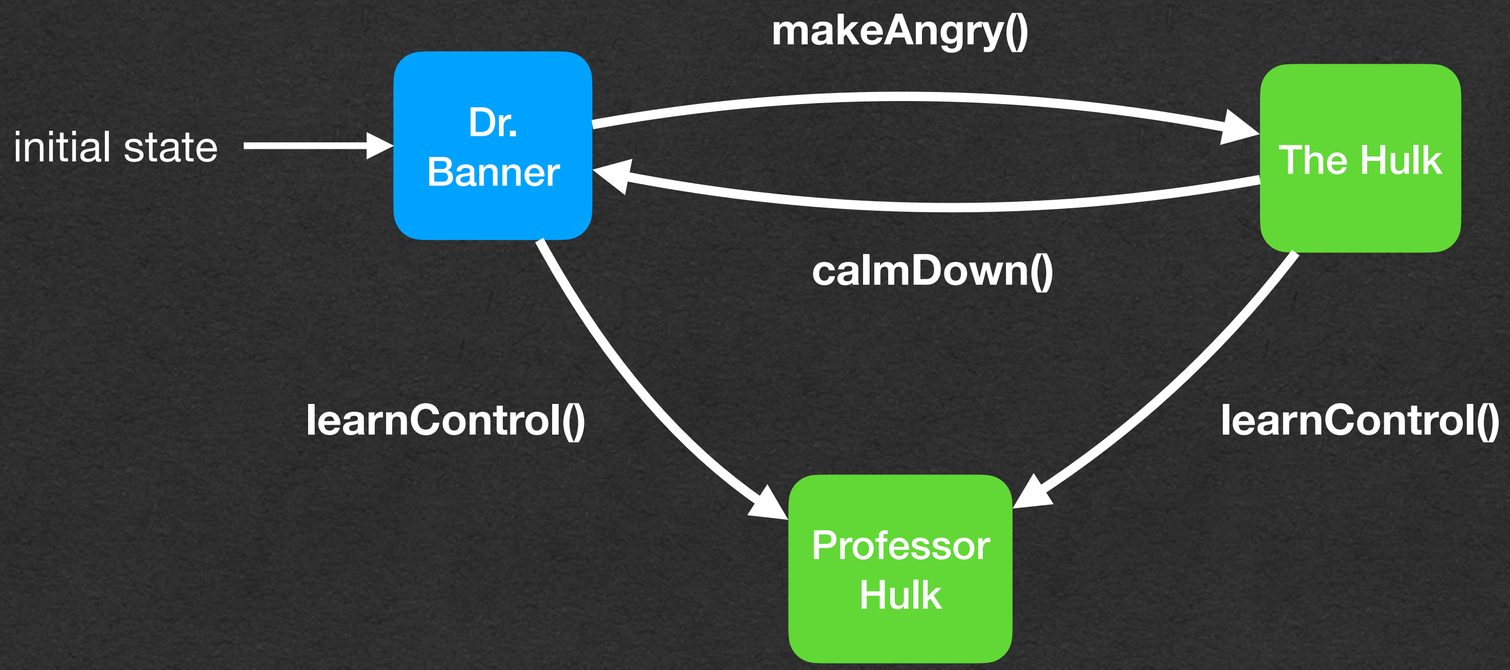
State Pattern - Example

- If we want functionality that is the same in all states
  - Add it to the class containing the state
  - [Or, add it to the State class so all states inherit that functionality]
- Bruce can become Professor Hulk from either of his other states
  - Add this transition to BruceBanner
- Note that there's no going back to the other two states once he becomes Professor Hulk

```
class BruceBanner {

  var state: State = new DrBanner(this)

  def makeAngry(): Unit = {
    this.state.makeAngry()
  }

  def calmDown(): Unit = {
    this.state.calmDown()
  }

  def useCar(car: Car): Unit = {
    this.state.useCar(car)
  }

  def fight(): Unit = {
    this.state.fight()
  }

  def learnControl():Unit = {
    this.state = new ProfessorHulk(this)
  }

}
```

State Pattern - Example

- **State Diagrams**
  - Visualize **states** and **state transitions**
  - Very helpful while designing with the state pattern
- The state diagram for Bruce Banner is as follows



State Pattern - Design

- Write your API
  - What methods will change behavior depending on the current state of the object
  - These methods define your API and are declared in the State class
- Decide what states should exist
  - Any situation where the behavior is different should be a new state
- Determine the transitions between states