State Pattern

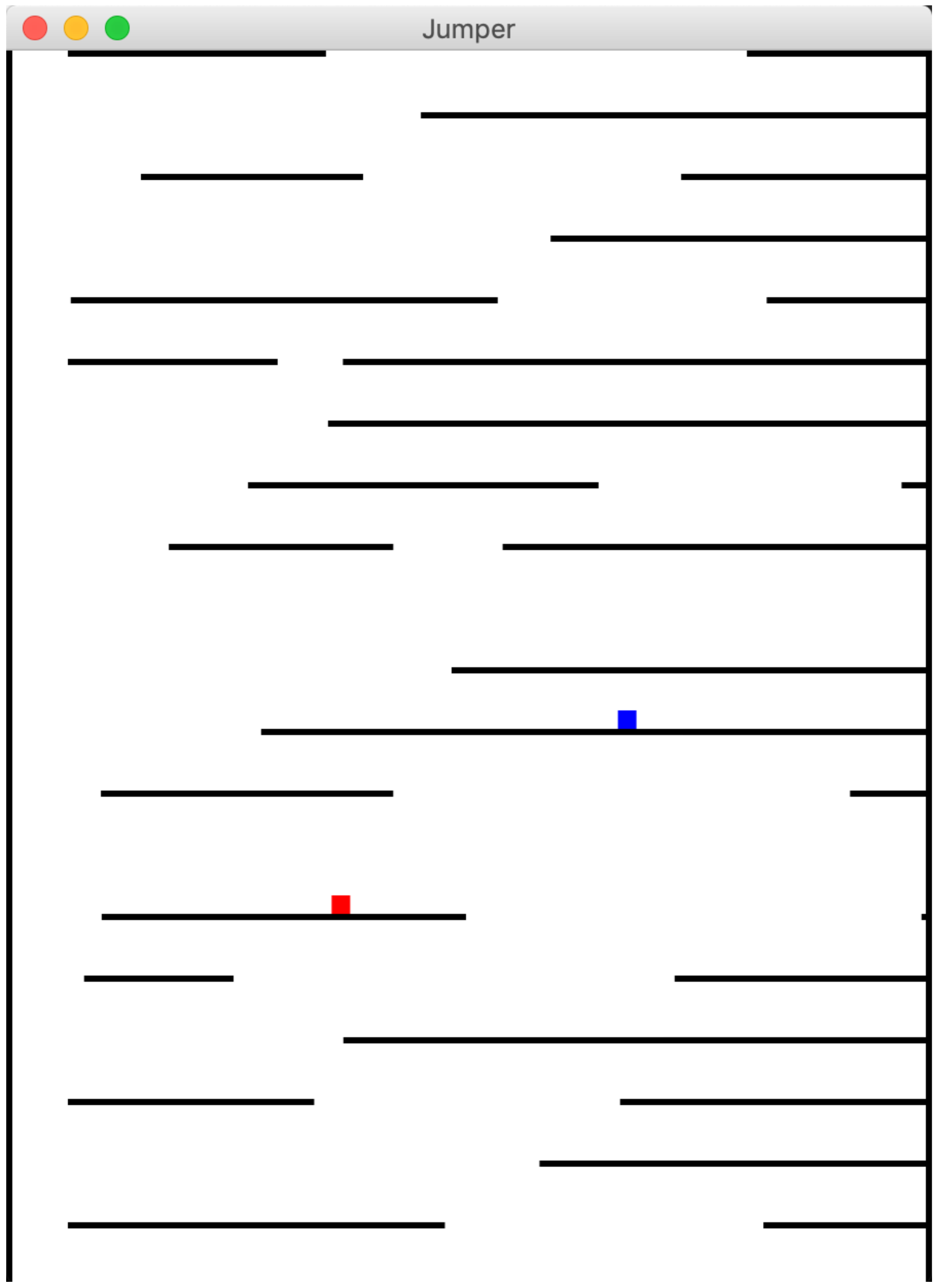
Jumper Example

Lecture Question

- During Lecture

Jumper

- 2 Player vertical scrolling platform
- Screens scrolls up as the players climb the platforms
- The bottom of the screen is game over
- **Goal**: Climb faster than the other player



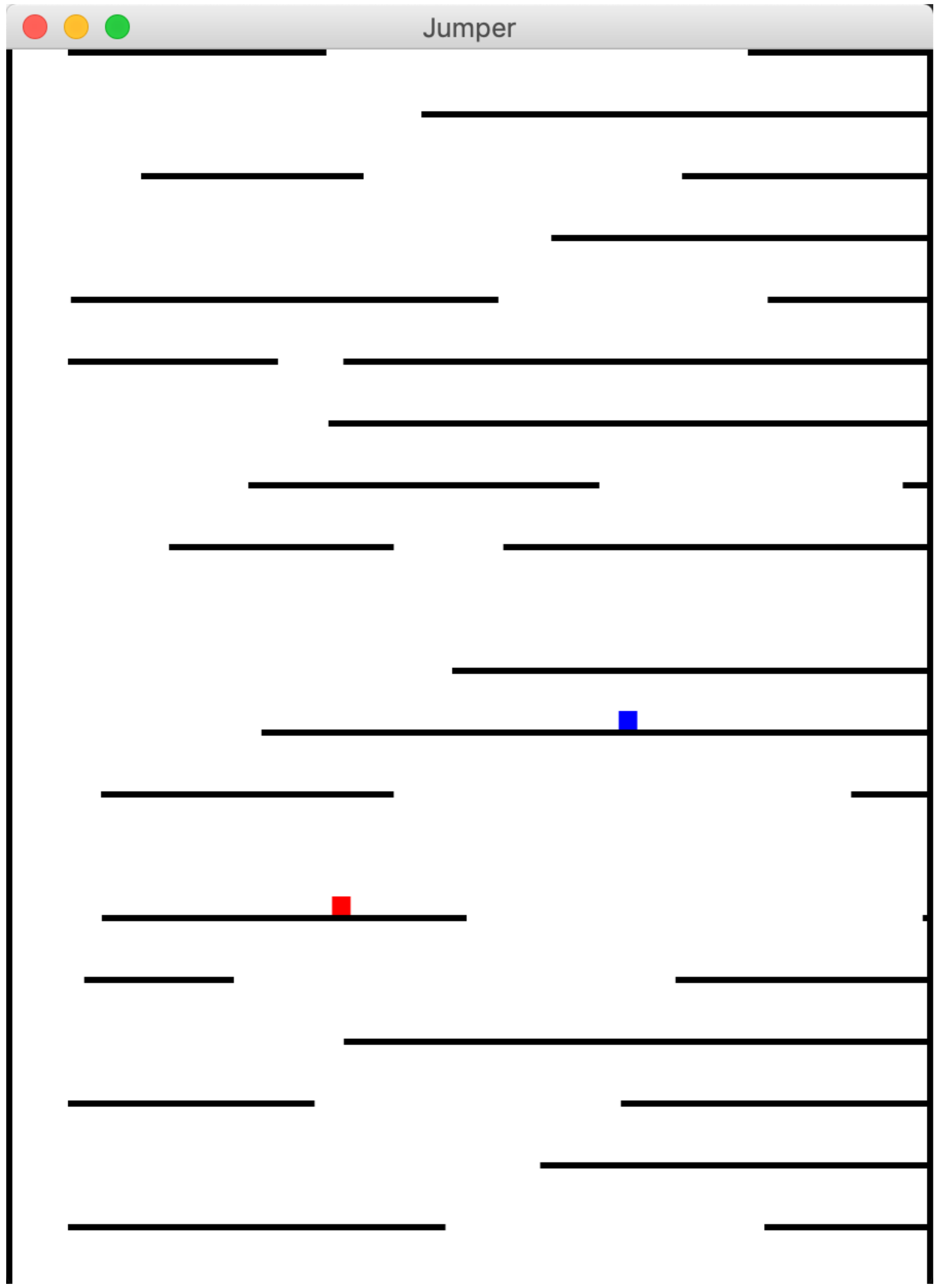
Jumper

We've already seen

- Physics

Next week

- GUI
- Keyboard inputs
- MVC architecture



Jumper - Physics

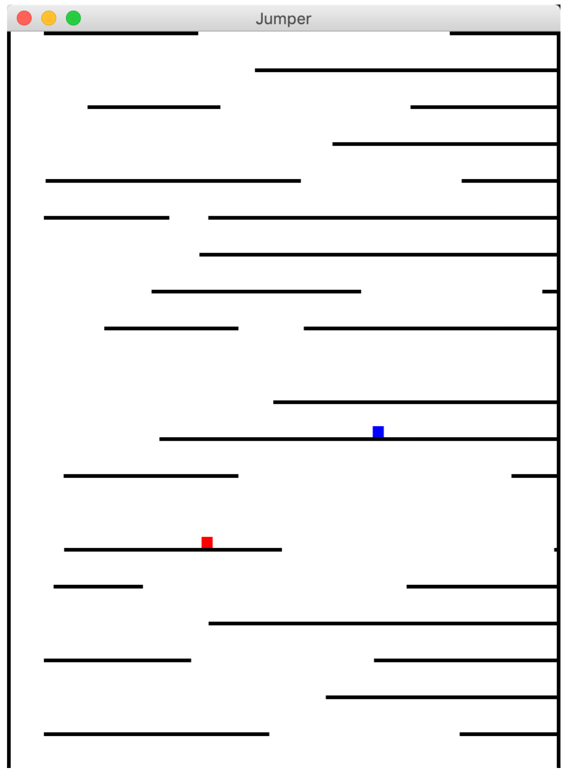
Walls and Platforms extend StaticObject

- Add behavior after collision with player

```
class JumperObject(location: PhysicsVector, dimensions: PhysicsVector)
extends StaticObject(location, dimensions){
  val objectID: Int = JumperObject.nextID
  JumperObject.nextID += 1
}
```

```
class Platform(location: PhysicsVector, dimensions: PhysicsVector) extends
JumperObject(location, dimensions) {

  override def collideWithDynamicObject(otherObject: DynamicObject, face: Integer): Unit = {

    if (face == Face.top) {
      otherObject.velocity.z = 0.0
      otherObject.location.z = this.location.z + this.dimensions.z
      otherObject.onGround()
    }

  }

}
```

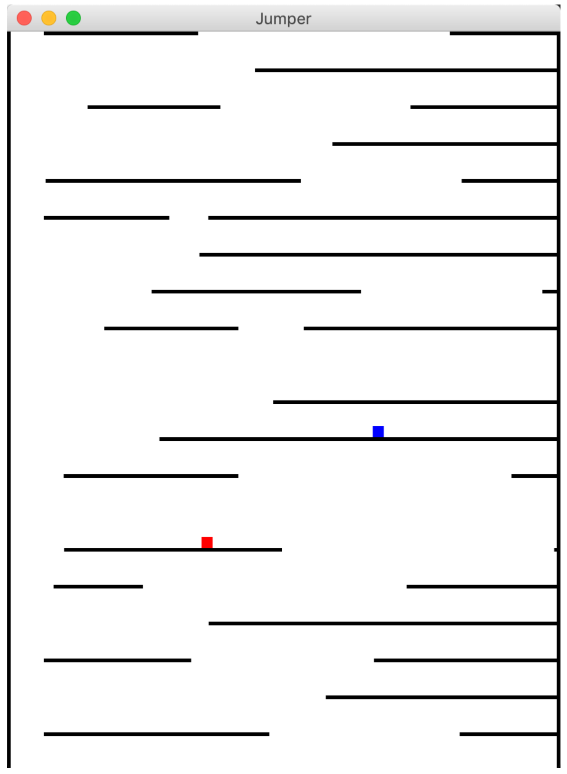
```
class Wall(location: PhysicsVector, dimensions: PhysicsVector) extends JumperObject(location,
dimensions){

  override def collideWithDynamicObject(otherObject: DynamicObject, face: Integer): Unit = {
    if(face == Face.negativeX){
      otherObject.velocity.x = 0.0
      otherObject.location.x = this.location.x - otherObject.dimensions.x
    }else if(face == Face.positiveX){
      otherObject.velocity.x = 0.0
      otherObject.location.x = this.location.x + this.dimensions.x
    }
  }

}
```



Jumper - Physics

Players extend DynamicObject

- Physics engine applies since all objects in our game are StaticObjects or DynamicObject
- The Player class will set its own velocity based on user inputs
  - Velocities are updated by gravity and collisions
  - User inputs are effectively the "intended" velocity
- How does the Player set its velocity?



```
class Player(playerLocation: PhysicsVector,
             playerDimensions: PhysicsVector
            ) extends DynamicObject(playerLocation, playerDimensions) {

  // ...

}
```

Jumper - Player

How does the Player set its velocity?

- User inputs
- States! <-- Good stuff

Only 3 inputs to control each player

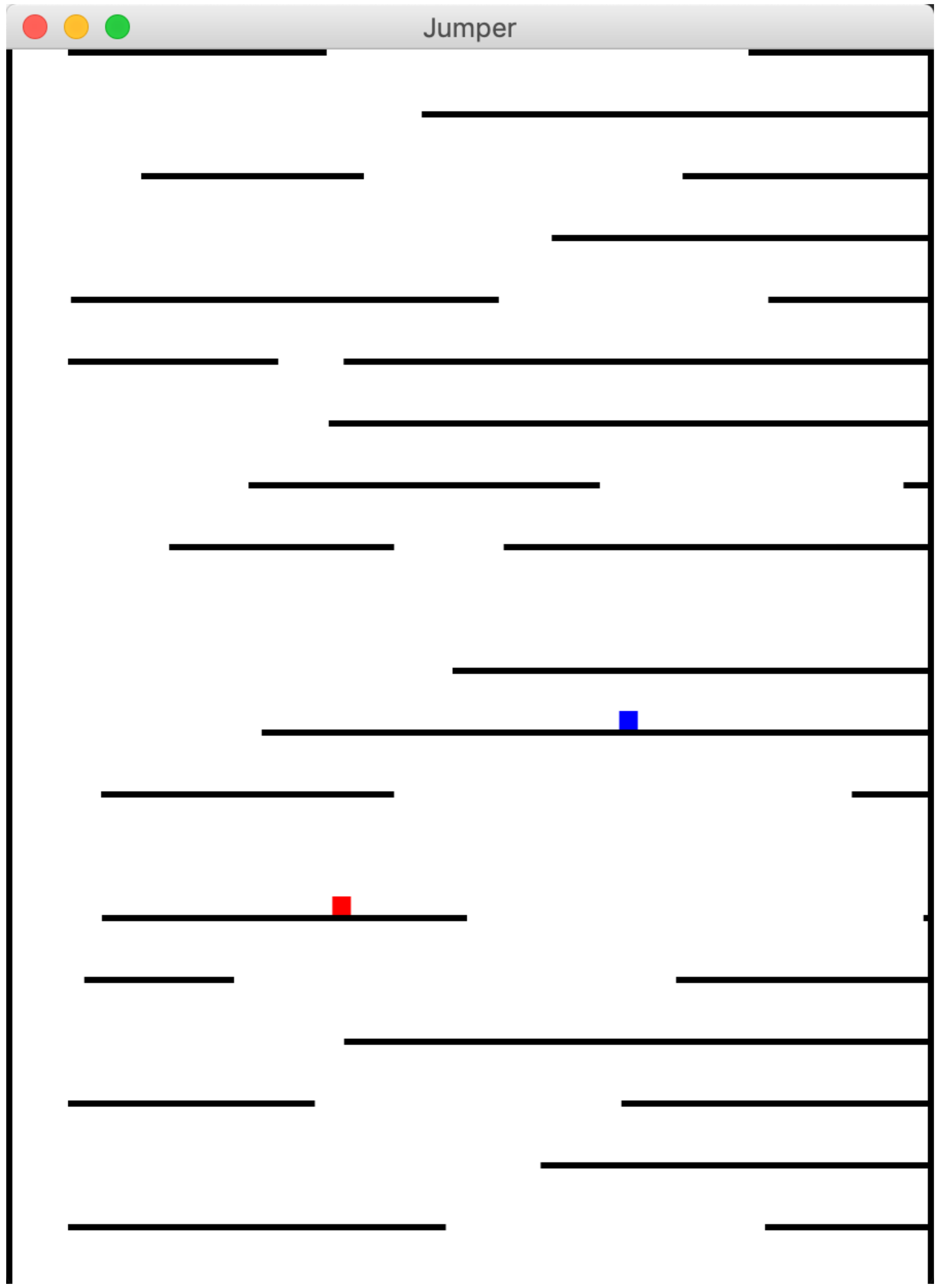
- Left button
- Right button
- Jump button

Player 1:

- a, d, w

Player 2:

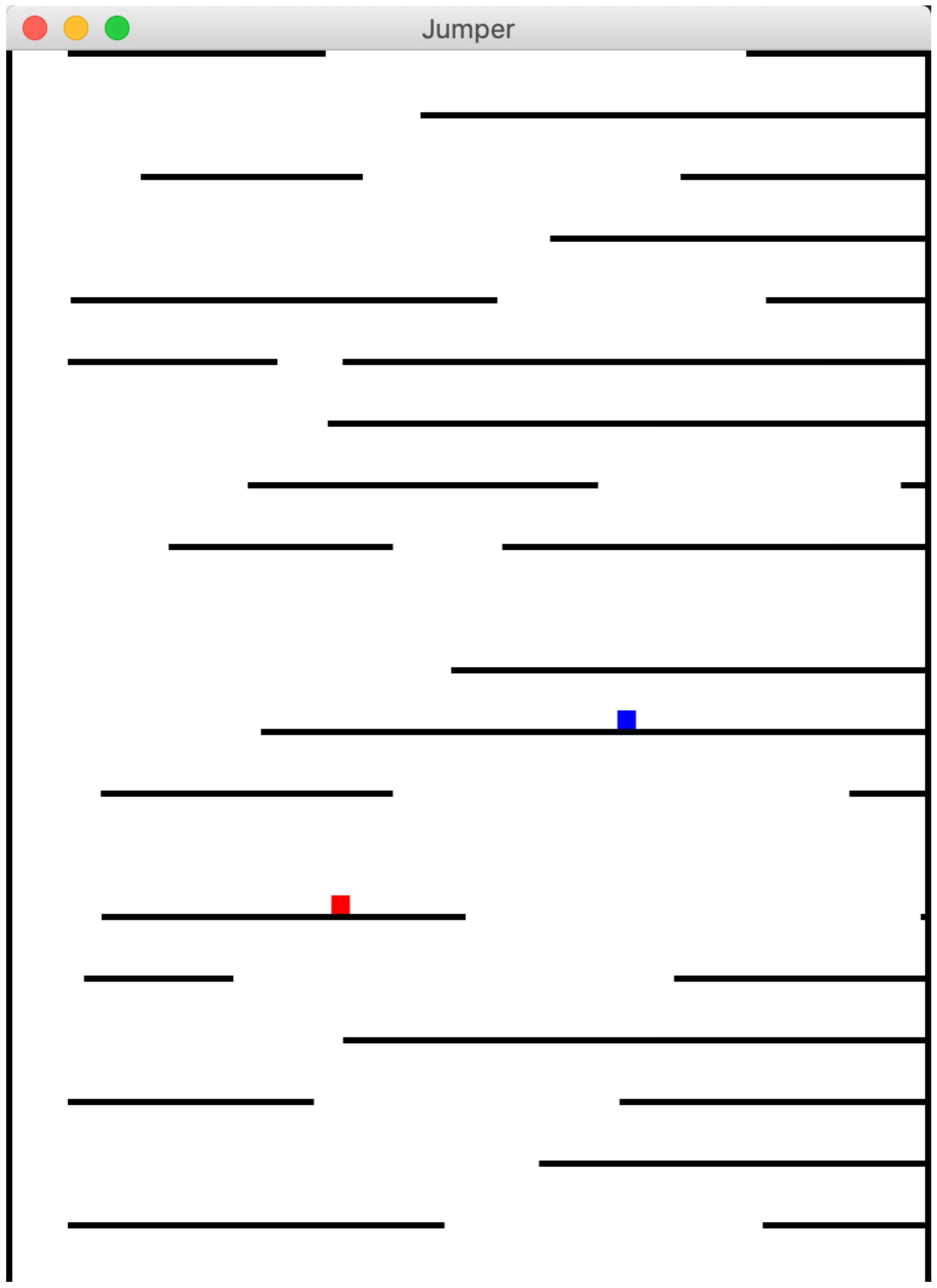
- Left, right, up arrows



Jumper Player Behavior

Each player should

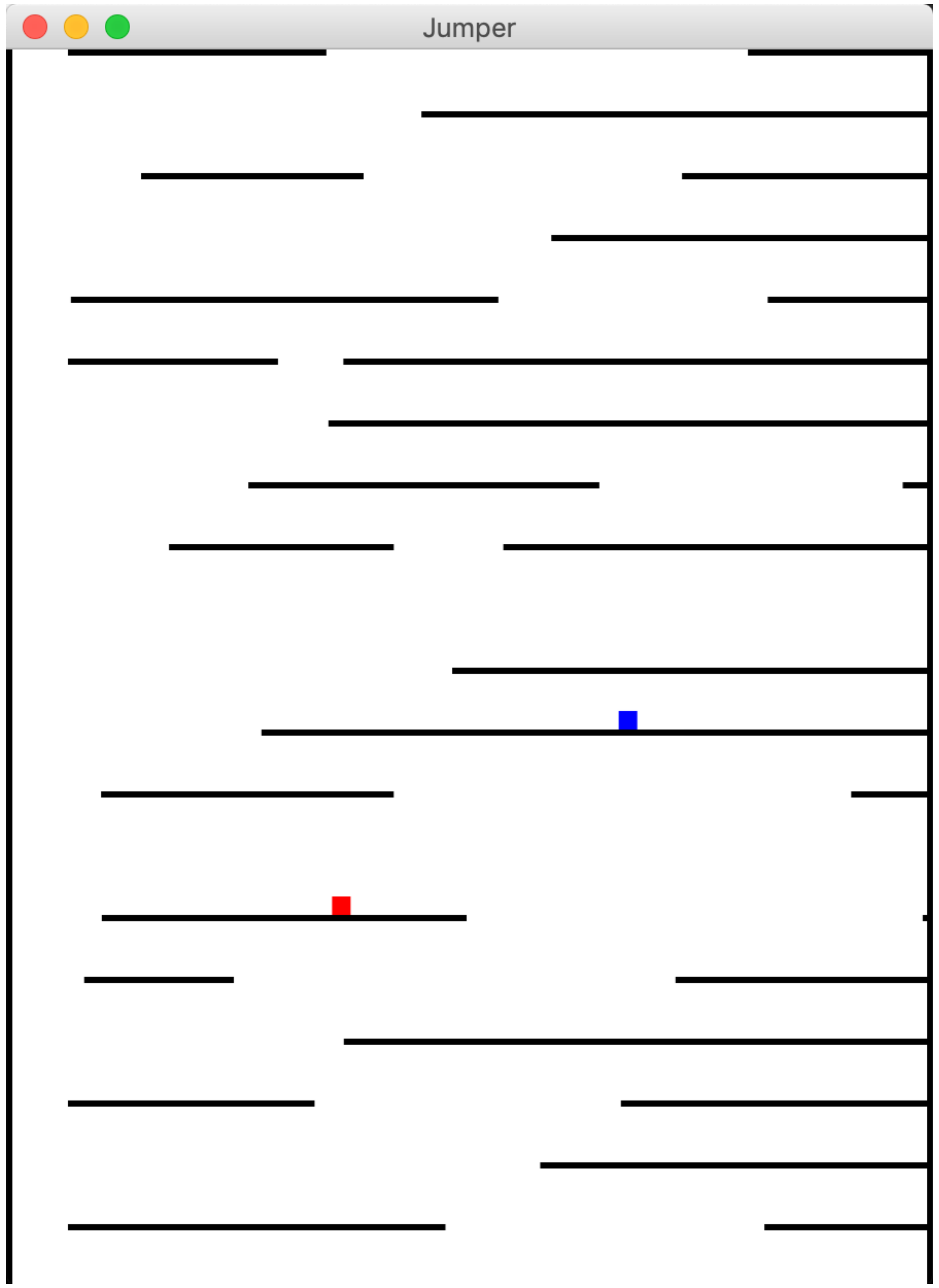
- Walk left and right when keys are pressed
- Jump when jump is pressed
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- Land on platforms while falling down
- Fall if walked off a ledge
- Block all inputs if the bottom of the screen is reached



Player behavior

We could write all this behavior without the state pattern

- Code will likely be hard to follow
- Difficult to add new features



Jumper Player Behavior

Each player should

- Walk left and right when keys are pressed
- Jump when jump is pressed
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- Land on platforms while falling down
- Fall if walked off a ledge
- Block all inputs if the bottom of the screen is reached

How to implement these features?

- 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 base state class
- Decide what states should exist
  - Any situation where the behavior is different should be a new state
- Determine the transitions between states

Lecture Question

Due: During Lecture

Jumper Player Behavior

Each player should

- Walk left and right **when keys are pressed**
- Jump **when jump is pressed**
- Jump higher if walking instead of standing still
- Jump at different heights based on **how long the jump button is held** after a jump
- Move left and right slower while in the air **if the direction is changed**
- Jump through platforms while jumping up
- **Land on platforms** while falling down
- Fall if **walked off a ledge**
- Block **all inputs** if the bottom of the screen is reached

How to implement these features?

- Write your API
  - What methods will change behavior depending on the current state of the object

API:

- left/right/jump pressed or released
  - 6 methods
- Land on a platform

Jumper Player Behavior

Each player should

- **Walk** left and right when keys are pressed
- **Jump** when jump is pressed
- Jump higher if **walking** instead of **standing** still
- **Jump** at different heights based on how long the jump button is held **after a jump**
- Move left and right slower while **in the air** if the direction is changed
- Jump through platforms while **jumping up**
- Land on platforms while **falling down**
- **Fall** if **walked** off a ledge
- Block all inputs if the **bottom of the screen is reached**

How to implement these features?

- Decide what states should exist

States:

- Standing
- Walking
- Jumping/Rising
- Falling
- Dead (Bellow Screen)

Jumper Player Behavior

Each player should

- **Walk left and right when keys are pressed**
- **Jump when jump is pressed**
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- **Land** on platforms while falling down
- **Fall if walked off a ledge**
- **Block all inputs if the bottom of the screen is reached**

How to implement these features?

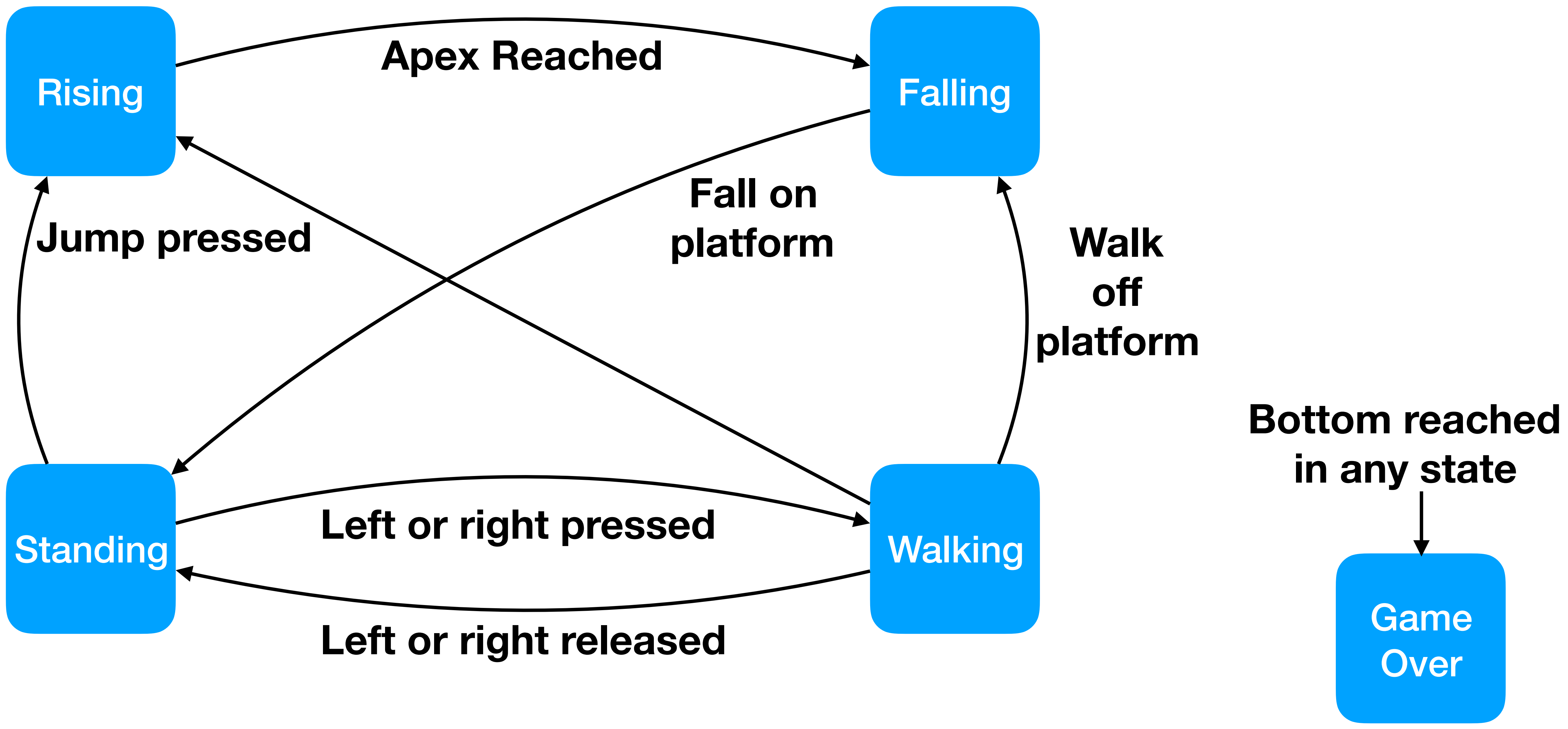
- Determine the transitions between states

State Transitions:

- Standing -> Walking
  - left/right pressed
- Walking -> Standing
  - left/right released
- Walking/Standing -> Jumping
  - Jump pressed
- Falling -> Standing
  - Land on a platform
- Walking -> Falling
  - Walk off a platform
- Jumping -> Falling
  - Apex of jump reached
- Any -> GameOver
  - Reach the bottom of the screen

Jumper Player Behavior

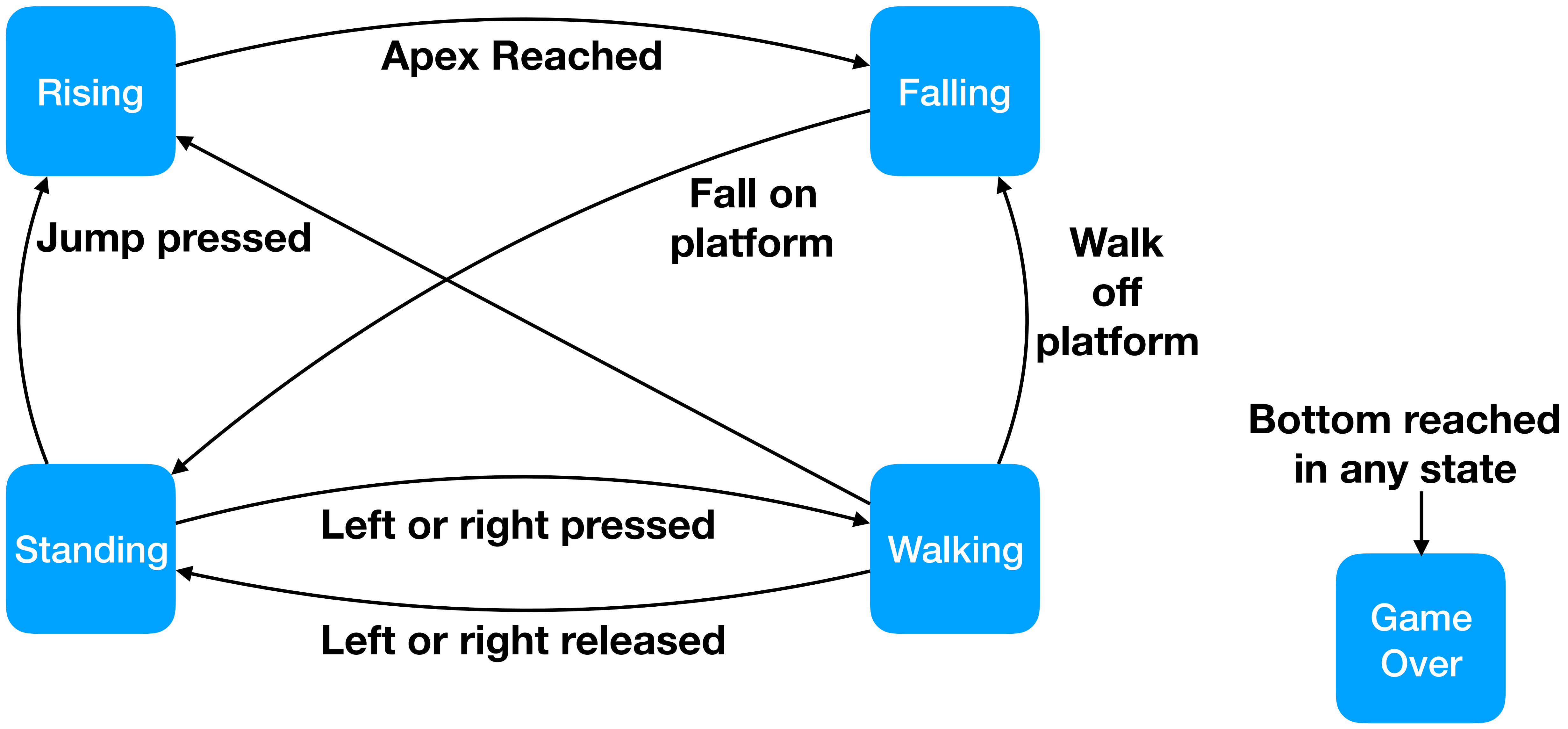
Let's visualize the states and transitions in a state diagram



Jumper Player Behavior

For each state implement the API methods with the desired behavior in that state

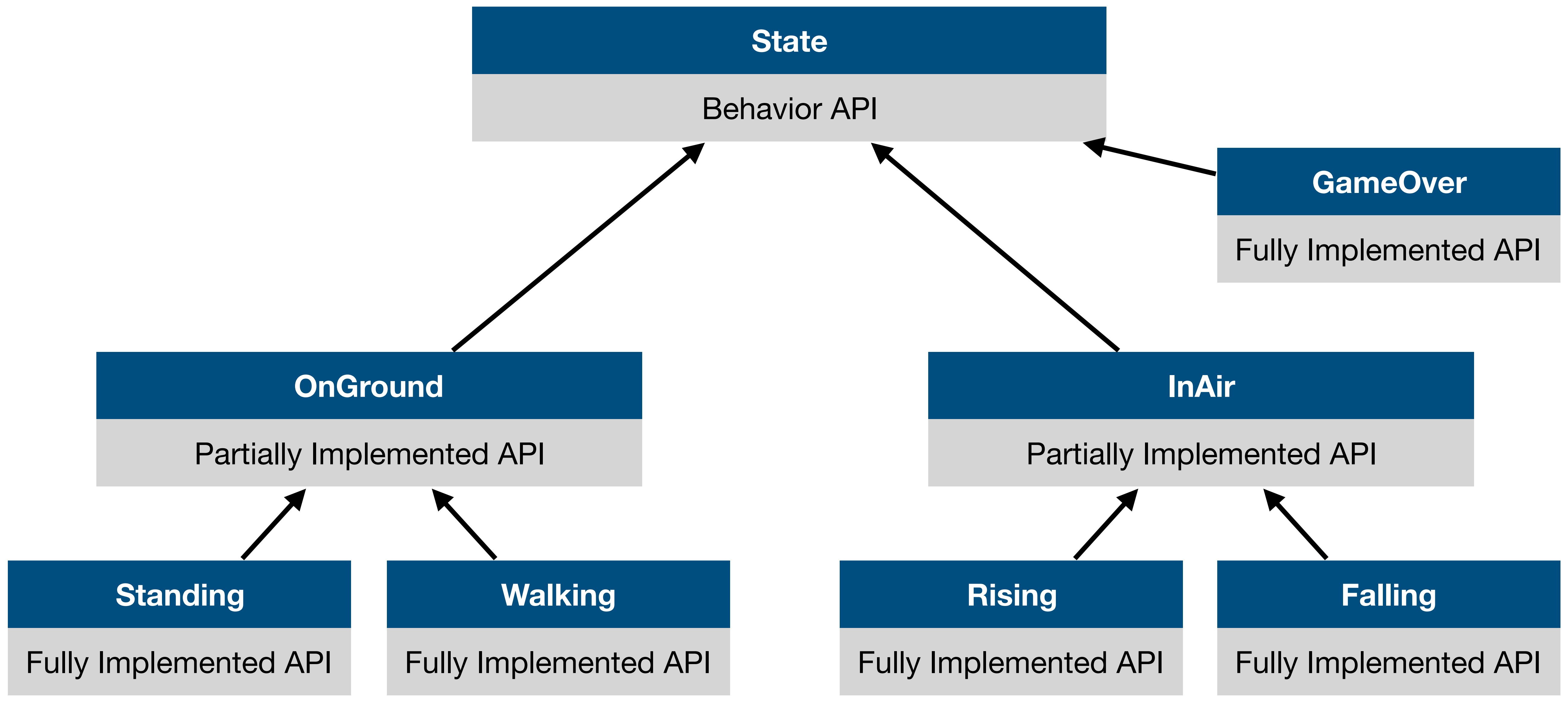
- Add default behavior in the state subclass



Jumper Player Behavior

Use inheritance to limit duplicate code

- Factor out common behavior between states into new classes



Adding Functionality

Task: Add a double jump to Jumper

- How can we add a double jump?
  - Players can jump 1 additional time while in the air
- With poor design
  - This could be extremely difficult!
  - May required modifying a significant amount of existing code
- With our state pattern
  - No problem at all

Adding Functionality

Task: Add a double jump to Jumper

- Add functionality to existing states
    - Rising and Falling states now react to the jump button by jumping again (Set velocity.z to the jump velocity)
- We'll add new states
    - RisingAfterDoubleJump/FallingAfterDoubleJump
    - Extend Rising/Falling respectively
    - Override the jump button press to do nothing
- Update state transitions
    - Press jump from Rising/Falling transitions to the respective AfterDoubleJump state
    - Reaching the apex in RisingAfterDoubleJump transitions to FallingAfterDoubleJump (Not Falling)

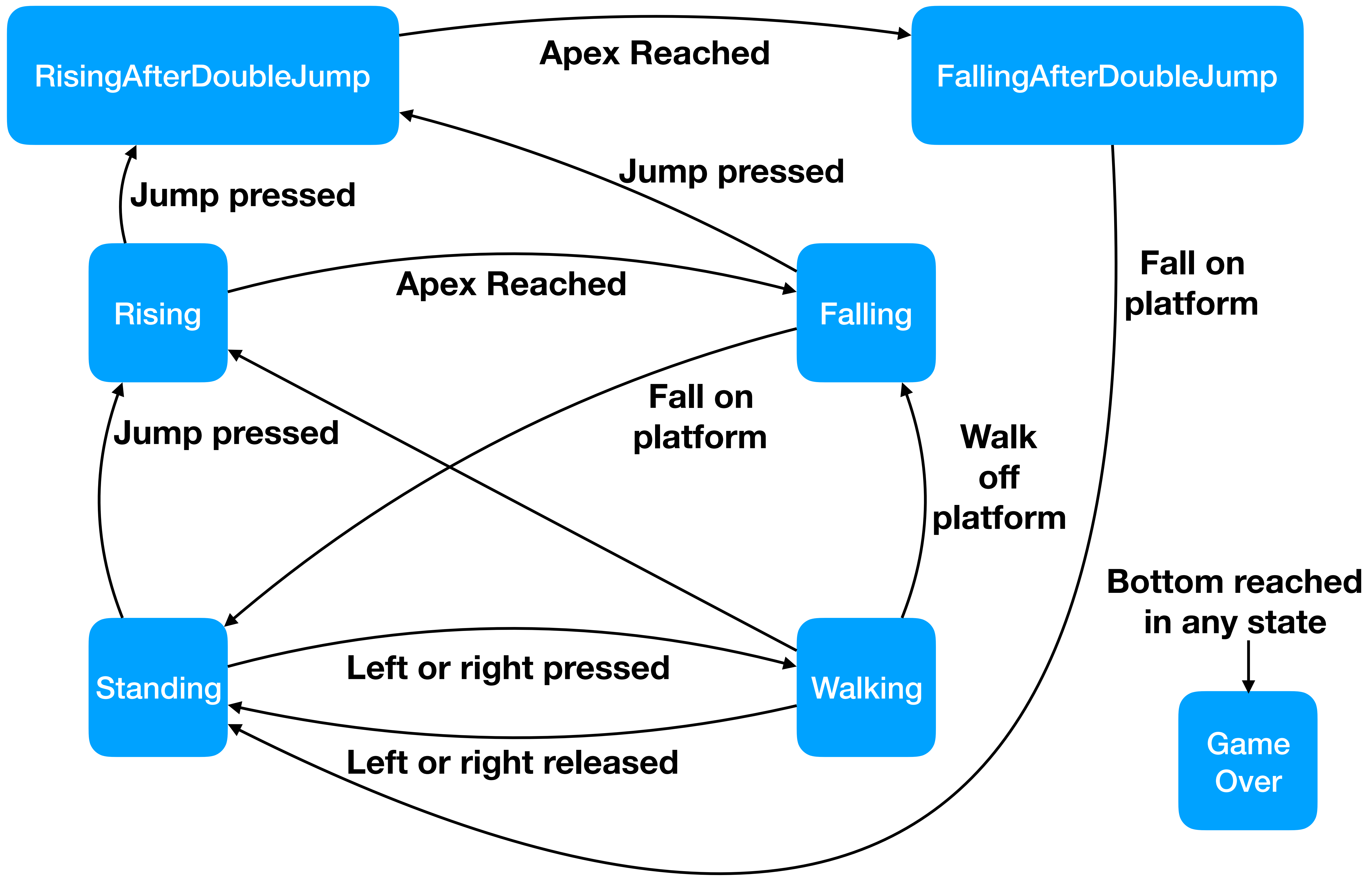
Adding Functionality

Task: Add a double jump to Jumper

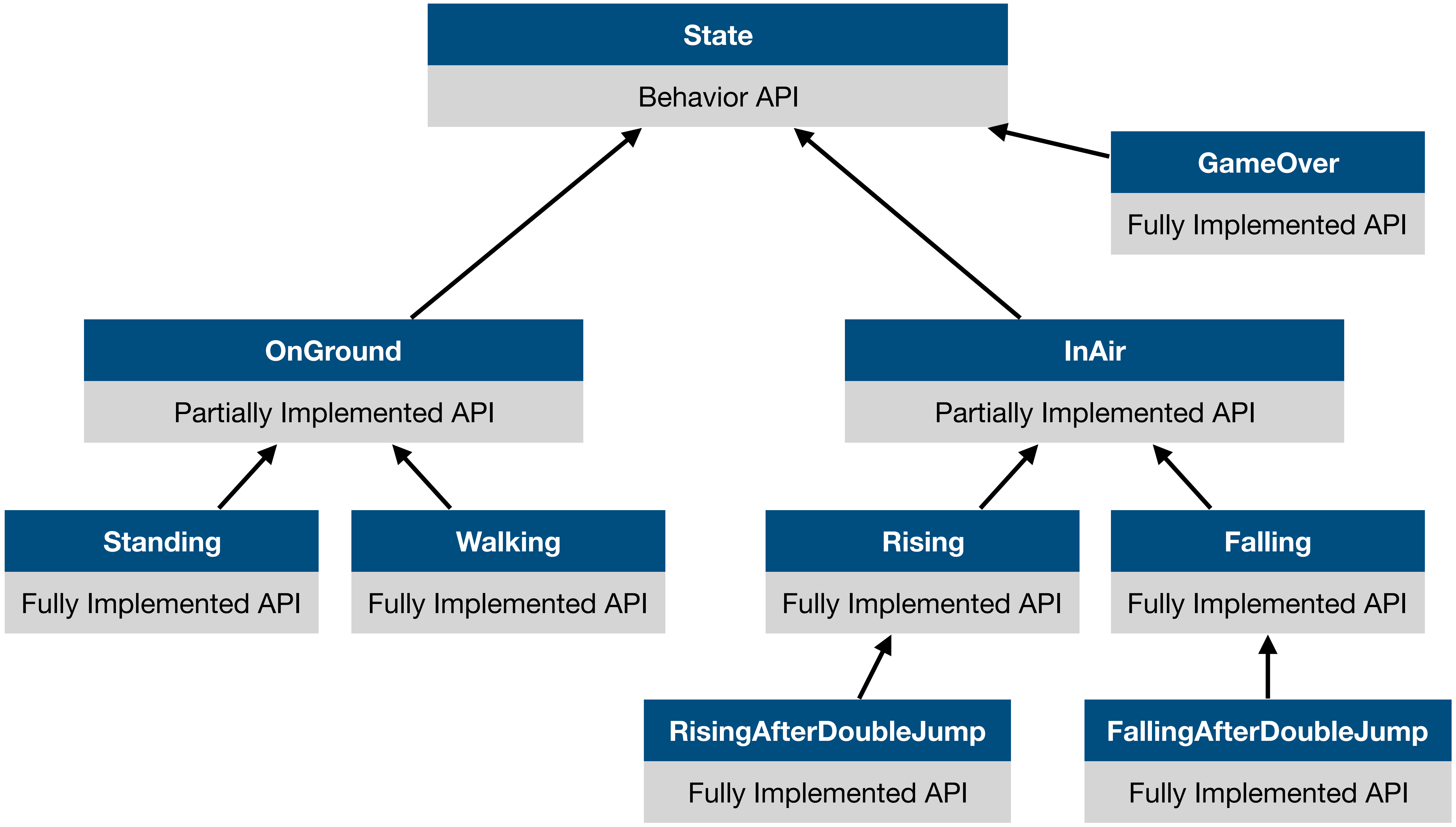
- This task could have been completed with a boolean flag instead of using new states
- If this approach is used for many features the code will be harder to maintain
- **More to the point**: What if your professor says you can't use control flow, but you have a situation where a button should only work once?
    - Try adding more states

```
var usedDoubleJump = false

override def jumpPressed(): Unit = {
  if(!this.usedDoubleJump) {
    player.velocity.z = player.standingJumpVelocity
    this.usedDoubleJump = true
  }
}
```

Jumper Player Behavior



Jumper Player Behavior



Lecture Question

- Since there is no lecture question to work on tonight

- Start your Calculator!
  - You will need to start early to do well on this homework
  - You have all the concepts you need for this homework
  - Start by designing your calculator like we just did with Jumper

Lecture Question

- If you want extra practice:

- Add a running state to Jumper
  - If you are in the walking state for a more than one second the player will move faster and jump higher