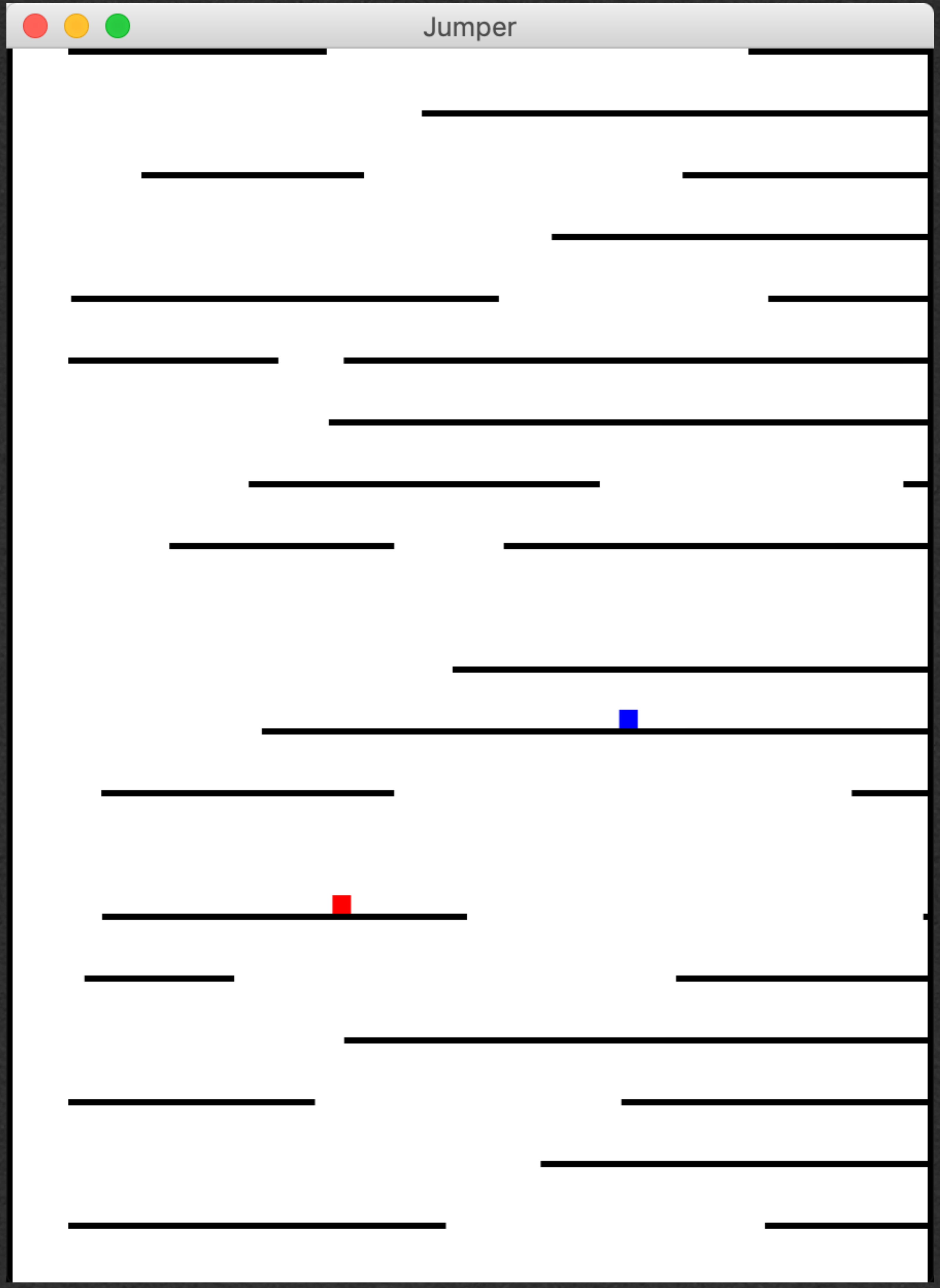
State Pattern

Jumper Example

Jumper

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



Jumper - Player

How does the player move?

- User inputs
- States! <-- Good stuff

Only 3 inputs to control each player

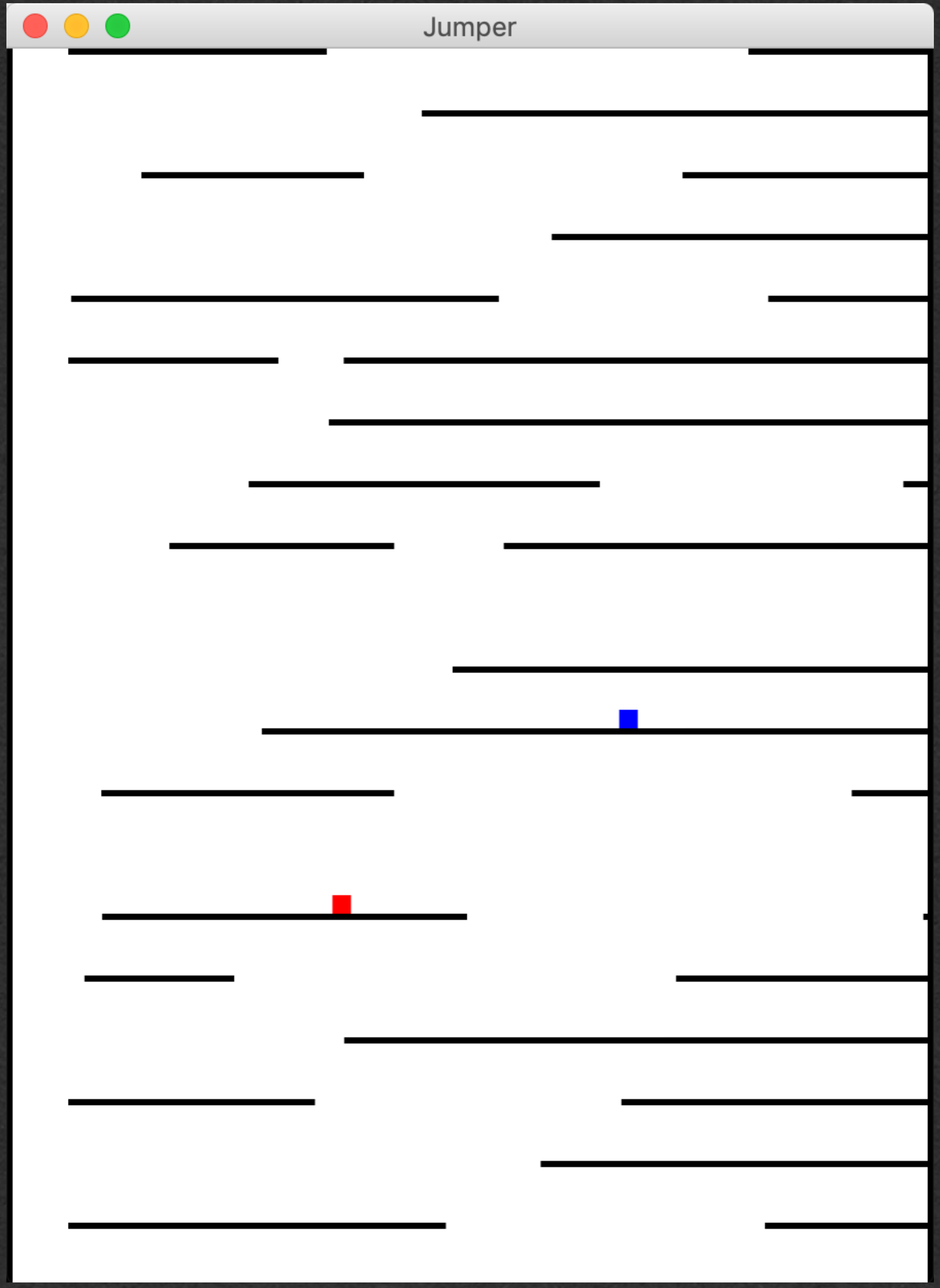
- Left button
- Right button
- Jump button

Player 1:

- a, d, w

Player 2:

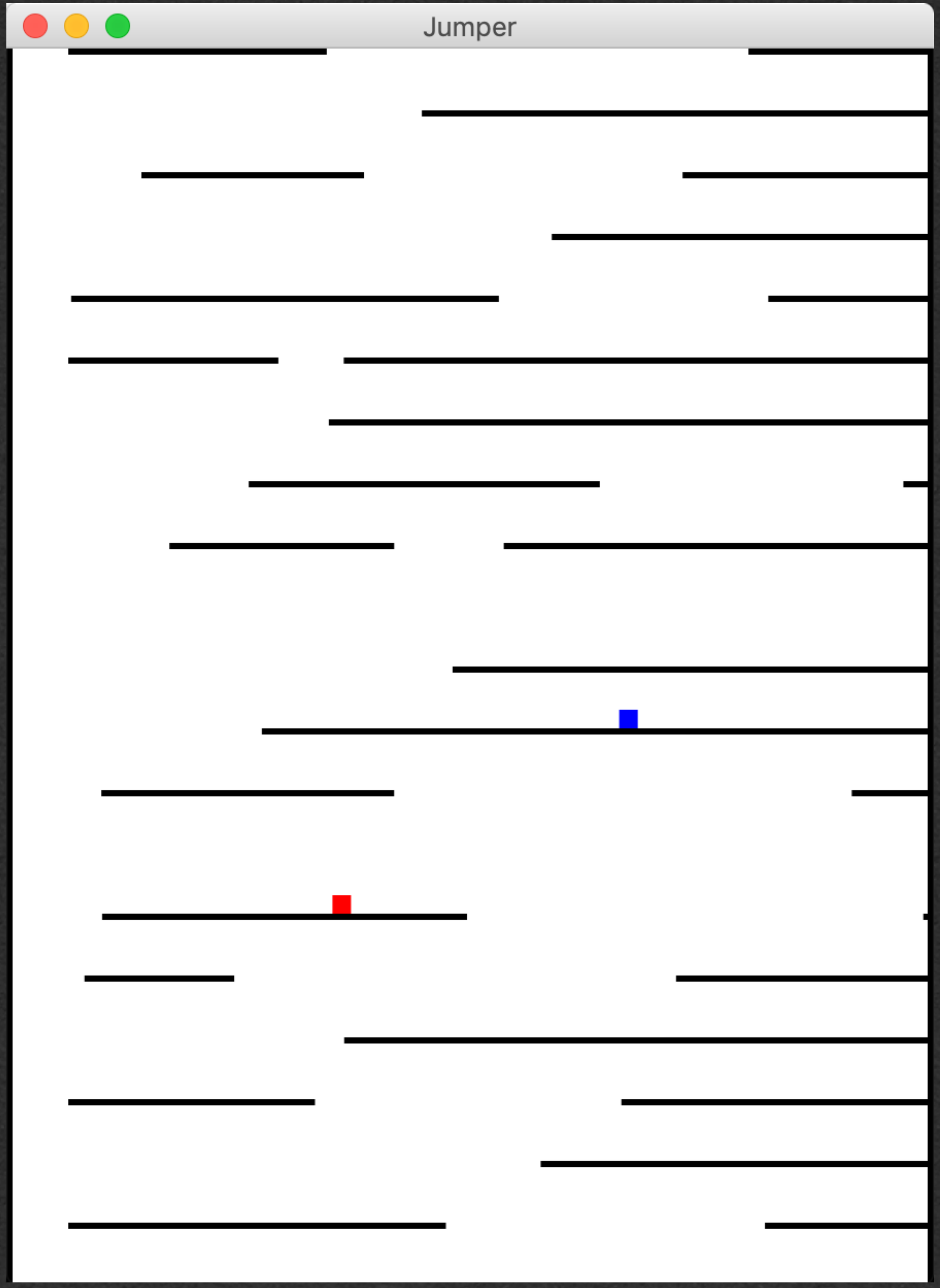
- Left, right, up arrows



Jumper Player Behavior

Each player should

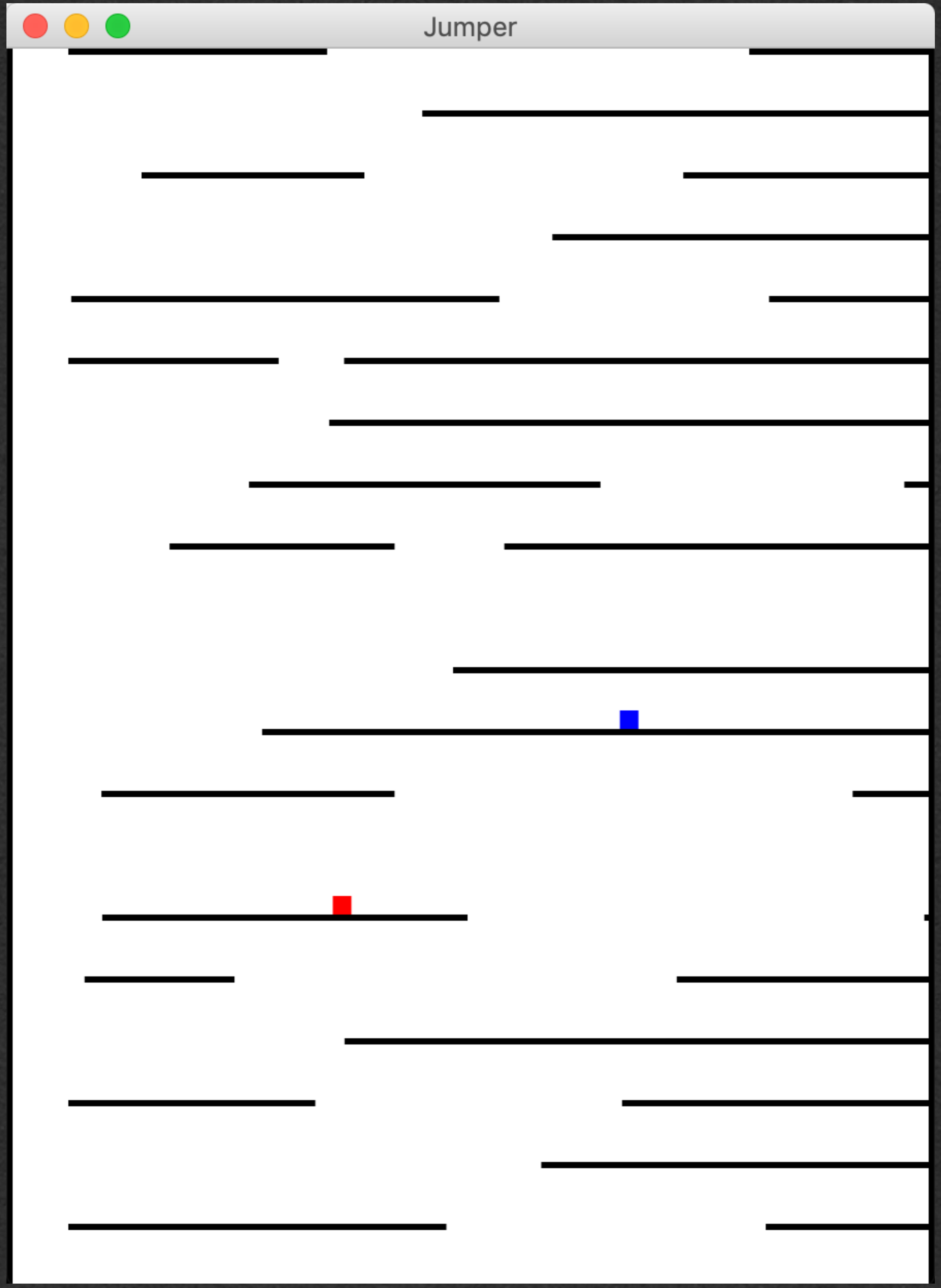
- Walk left and right when keys are pressed
- Jump when jump is pressed
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms 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 state abstract class
- Decide what states should exist
  - Any situation where the behavior is different should be a new state
- Determine the transitions between states

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?

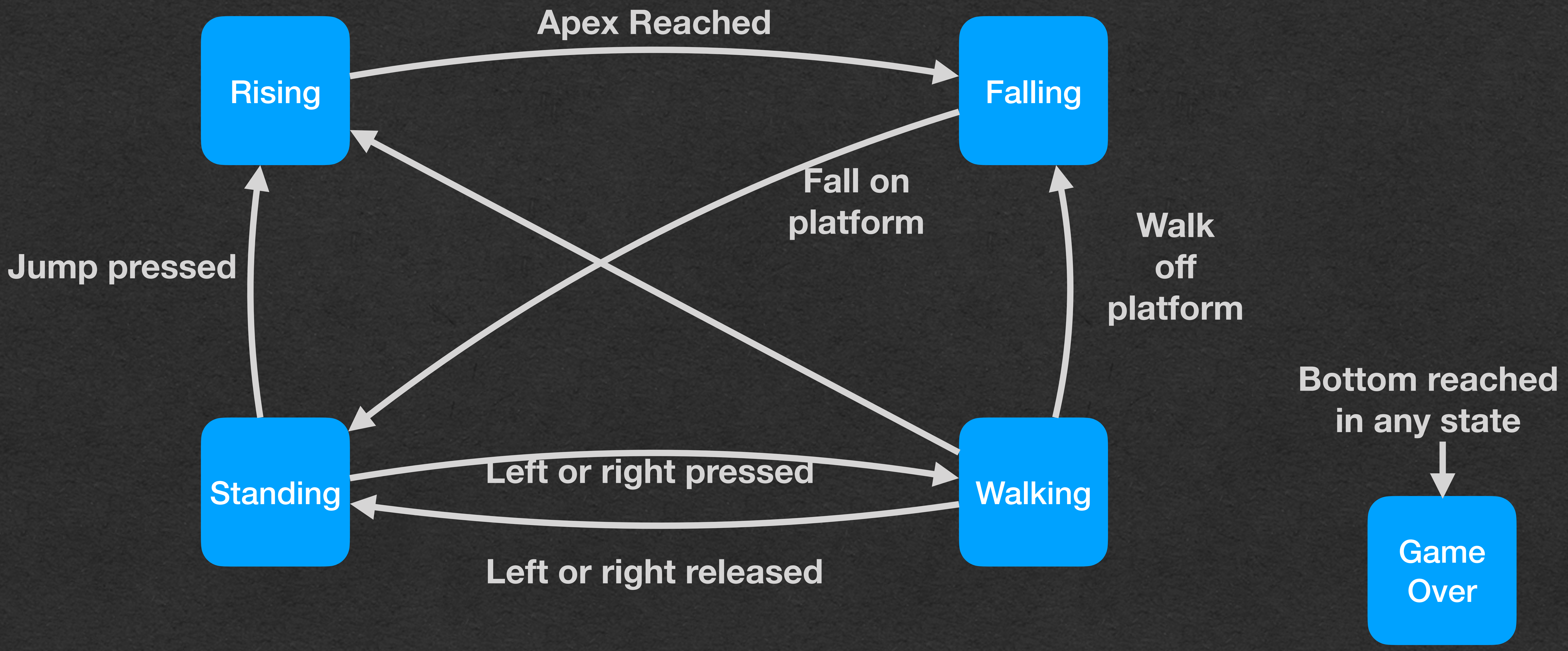
- Determine the transitions between states

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

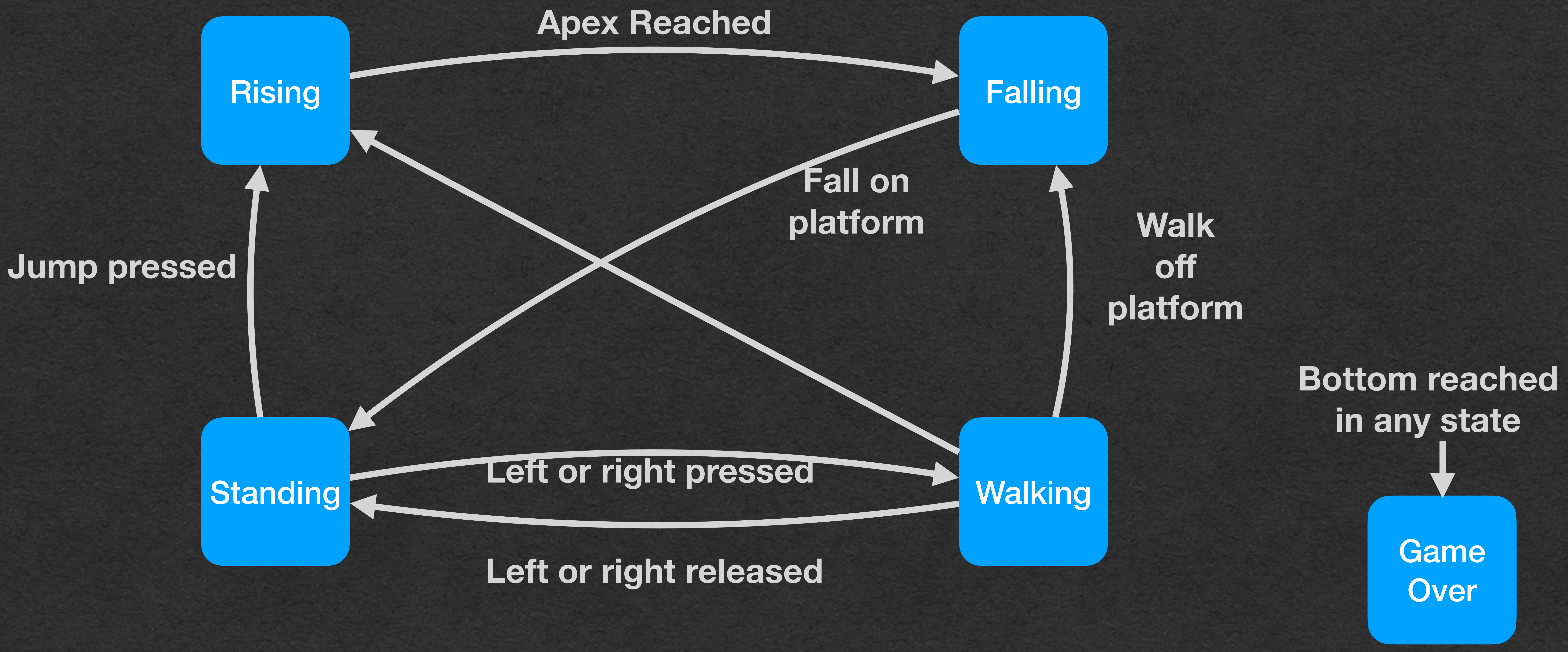
Let's visualize the states and transitions in a state diagram



Jumper Player Behavior

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

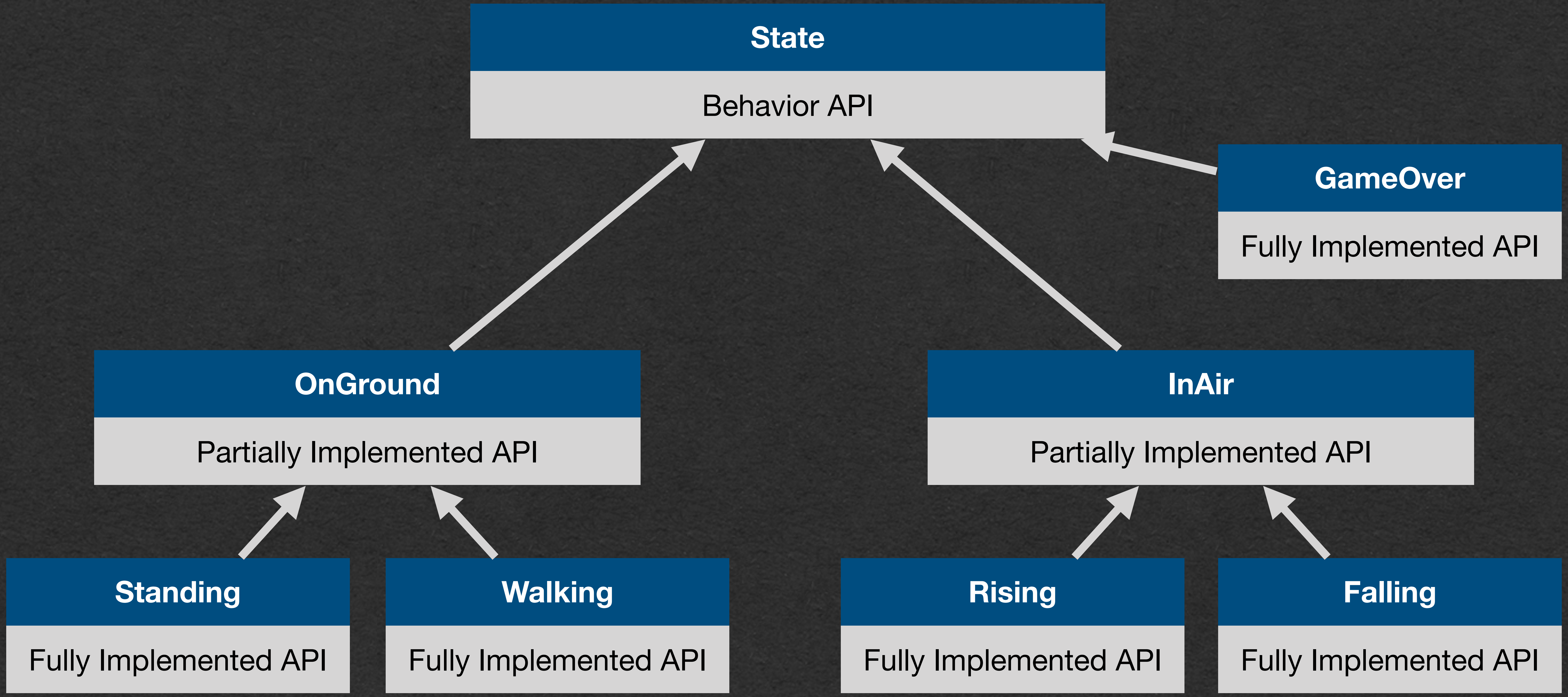
- Add default behavior in the state subclass



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

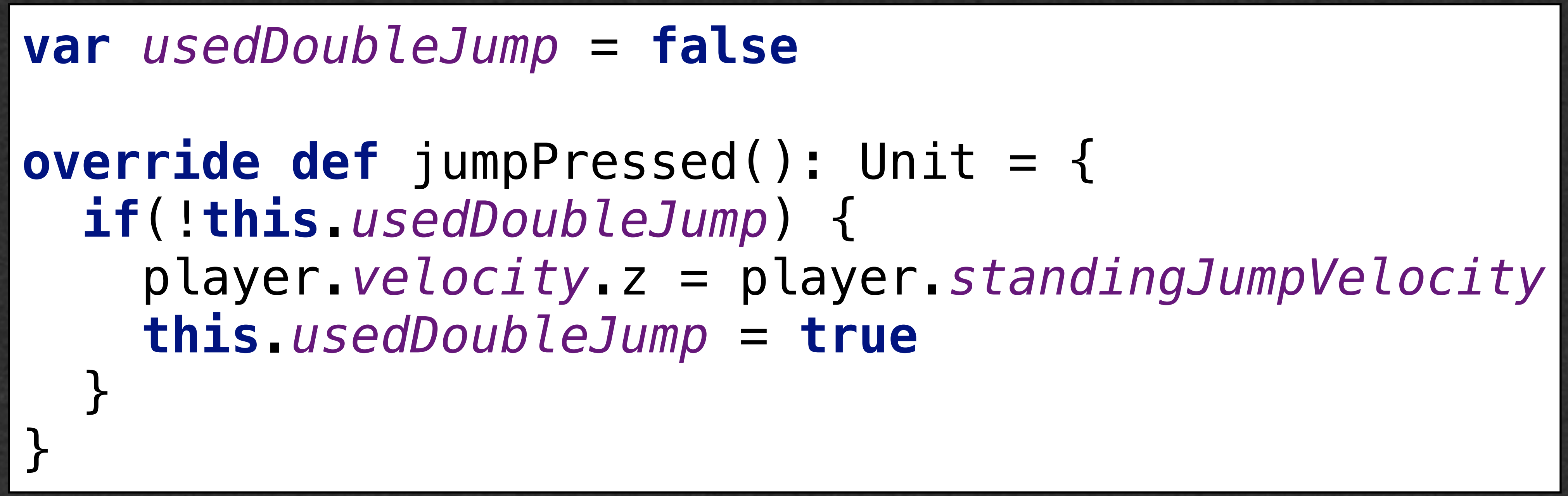
Task: Add a double jump to Jumper

- 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

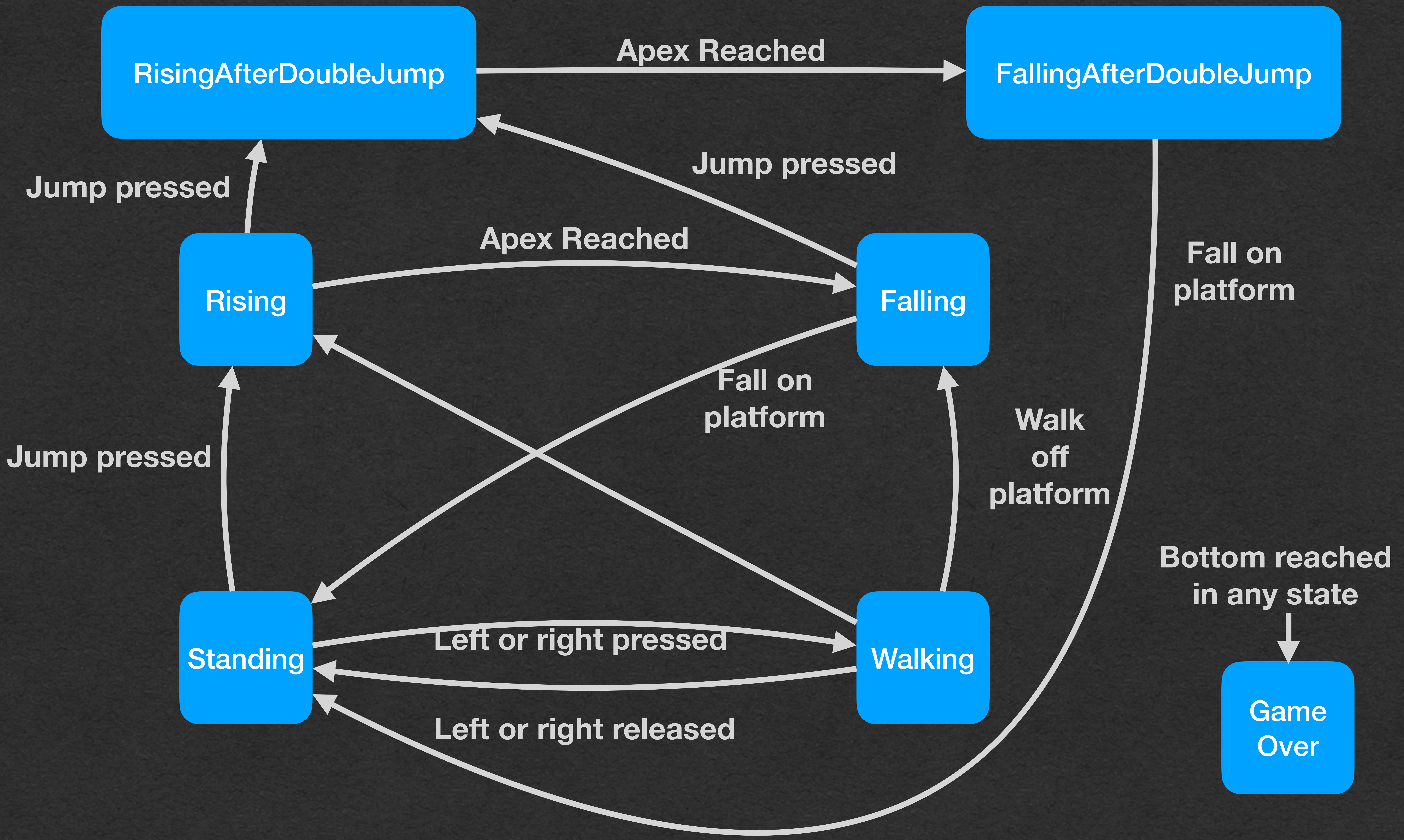
- This task could have been completed with a boolean flag instead of using new states



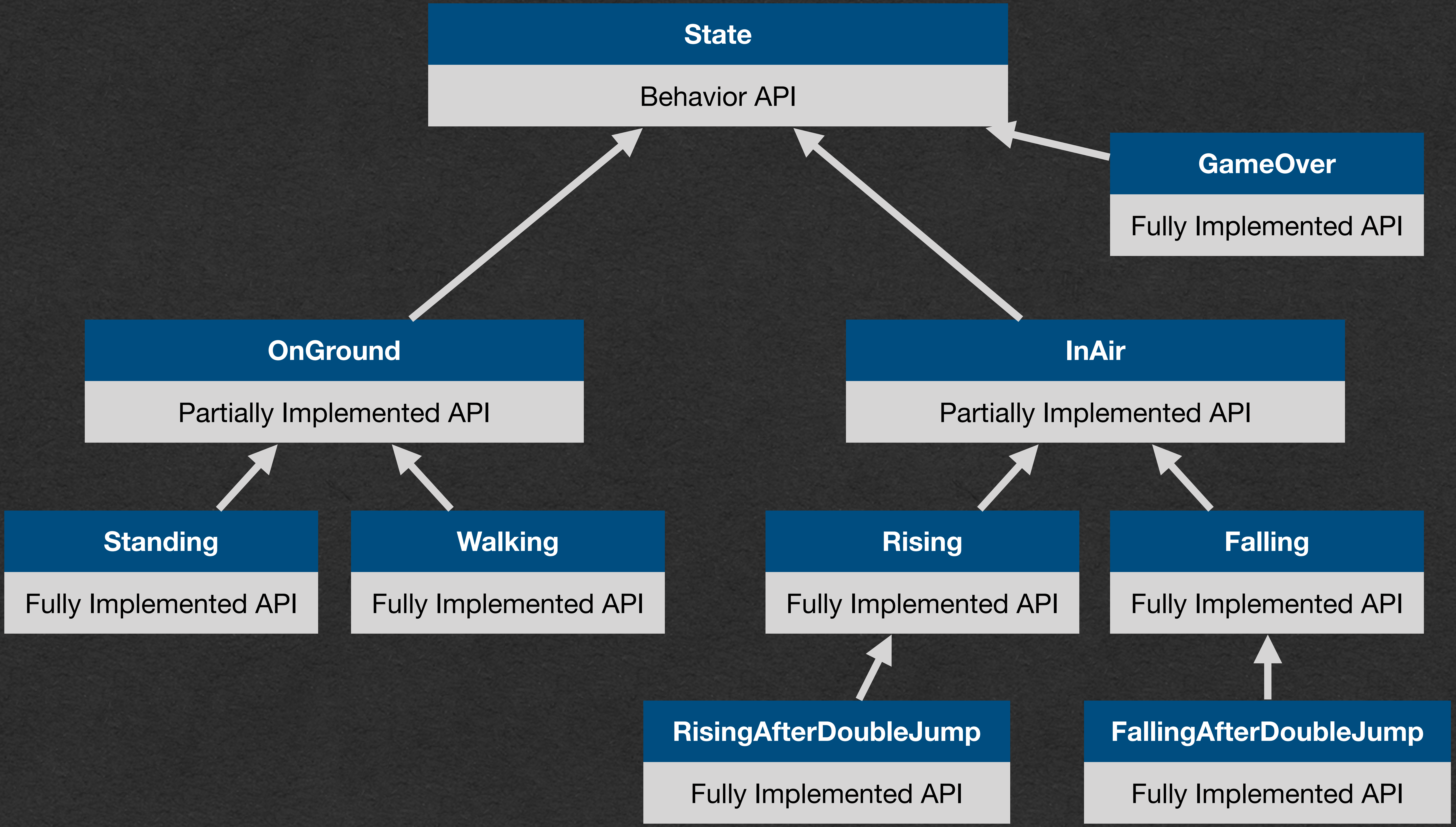
```
var usedDoubleJump = false

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

- 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 conditionals, but you have a situation where a button should only work once?
  - Try adding more states

Jumper Player Behavior



Jumper Player Behavior


State
Behavior API
GameOver
Fully Implemented API
OnGround
Partially Implemented API
InAir
Partially Implemented API
Standing
Fully Implemented API
Walking
Fully Implemented API
Rising
Fully Implemented API
Falling
Fully Implemented API
RisingAfterDoubleJump
Fully Implemented API
FallingAfterDoubleJump
Fully Implemented API