MVC

Model-View-Controller Architecture

MVC

- Software **architecture pattern**
  - A way to organize the code of an entire project
  - As opposed to **design patterns** which solve a specific problems within a project
- Separate code into a Model, View, and Controller
  - Decouple the project into 3 pieces
- All three parts work independently and communicate with each other through APIs

API

- In CSE115 you've seen **web** APIs which have various endpoints
- An API is a set of functions/methods that can be called
- In the state pattern, define an API for the state
    - These are the methods that can be called and are deferred to the current state for functionality
    - Other classes only look at the API and call those methods
        - List of ways of interacting with the object
- The methods of any class/object define an API
- Can change functionality, just don't change the API
    - Ex. We can add dynamic collisions to the physics engine. If we don't change the way updateWorld is called, all games using the engine now have dynamic collisions
- Changing the API (ex. changing a return type from Double to Int) will break all code using that API

API

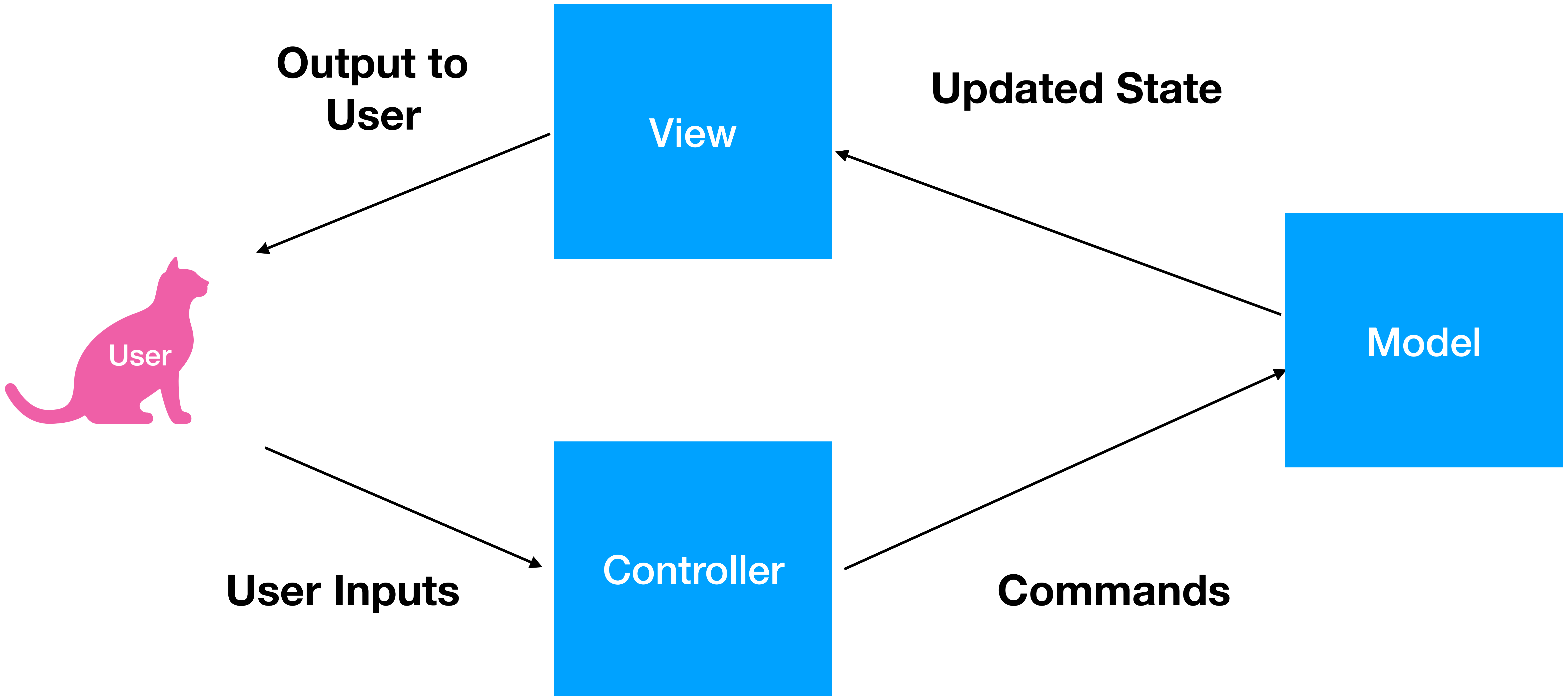
- Can change functionality if the API remains the same
- Example:
  - We can add dynamic collisions to the physics engine
  - If we don't change the way updateWorld is called, all games using the engine now have dynamic collisions

- Changing the API will break all code using that API
- Example: Changing a return type from Double to Int will cause type mismatch errors in any code calling that API method

MVC

- Model (Data and Logic)
  - Controls the app and its data
  - The core of the app
- View (Display)
  - Visualizes the app
  - No logic
- Control (User Inputs)
  - Handles user inputs
  - Calls model API methods based on inputs

MVC


Output to User
View
Updated State
User
Model
Controller
User Inputs
Commands

MVC - Model

- The core of the app
- Most of the code you've written so far in CSE115/116 is part of a model
    - Physics Engine handling how objects move
    - Calculator logic when buttons are pressed
- Controls the logic and functionality of the app
- Maintains the data
    - Controls any data structure, databases, and files related to how the program behaves
- **Has no knowledge of the user of the app**
- Functionality accessed through an API

MVC - View

- Displays the state of the app to the user
- **Output only**
- No logic
  - The view cannot change the state of the app
- Since the view is output only and does not alter the app, it can change and be replaced without affecting the app itself
- Can test the logic of an app without using the view
- Can have the same app with a CLI (command line interface) and a GUI (graphical user interface)
- Can have the same app with a web front-end and a desktop front-end!

MVC - Controller

- Handles user inputs
- In ScalaFX, defined by EventHandlers
- Processes user inputs and converts them into calls of the model API
- Can validate and block invalid inputs
- Acts as a barrier between the GUI and the model
    - If the GUI changes, replace view and controller and model remains unchanged

MVC - Advantages

- Focus on 1 part of a project at a time
  - Reduce spaghetti code
  - Divide work among team members
    - Just agree on the APIs
- Views can be easily replaced
- Keeps code organized
- Easier to add new features
  - Model can add features as long as API remains unchanged

MVC on the Web

- Model runs on the server
- View runs in the browser (HTML/CSS)
- Controller can run on both
    - JavaScript in the browser converts user inputs into AJAX requests
    - Server validates the data and sends the commands to the Model

MVC - Jumper

- Model API
  - Left, right, jump pressed for each player
  - Allows view to access all data
- Controller
  - Convert W, A, D, ←, ↑, → key presses into model API calls
- View
  - Displays all game objects to the player
  - Receives absolute locations of all objects from model
    - Computes vertical scroll and translates objects accordingly

MVC - Calculator

- Model API
  - Up to you to decide which methods are called by the controller (Can correlate with the button presses directly)
  - displayNumber(): Double is called by the view to determine what should be displayed to the user
- Controller
  - Each button on the calculator has an event handle for you to implement
  - Testing is done through these handlers to allow you to design your own model API
- View
  - Uses a grid pane for more control over element placement
  - Separate CalculatorButton class to easily change the appearance of all buttons
  - Calls displayNumber to update the display whenever the mouse is clicked on the GUI

MVC - Calculator

- Model is not aware of ScalaFX
- If we want to build a GUI using a different library
    - No need to change the model at all
    - Build a new view and controller to call the same model API methods

MVC - Project

- LA2, demo 1, LA4 are all part of your model
- Demo 2 is all about your view [and part of your controller]
- Your view in demo 2 will access from the model JSON strings containing
    - The overworld map
    - All party locations and state on the map
    - Status of all characters in each battle
- Your controller for demo 2 will send to the model
    - User inputs on the overworld map
    - Actions chosen by the player in battle

MVC - Project

- The rest of the controller and model will be developed for demo 3
- The model will be networked and be able to handle inputs from the desktop and web versions
  - Model won't even know if an input is from the web or desktop version
- Two different GUIs are completely compatible using MVC as long as they both use the model API
- Communication abstracted through JSON strings
  - GUIs are written in 2 different languages so we can't use language specific types

LQ - Chat App

- For the lecture question you'll finish a chat app using MVC
    - The chat app allows a user to send a message by clicking a send button
    - The model API contains a method for sending a message (Model is unaware of the send button)
    - Controller listens for the button press and calls the appropriate model API method
- If we want to allow the user to also press enter to send a message:
    - Only change the controller to listen to the enter key press and call the model API method
    - Model only cares that a message was sent. It does not care how it was sent

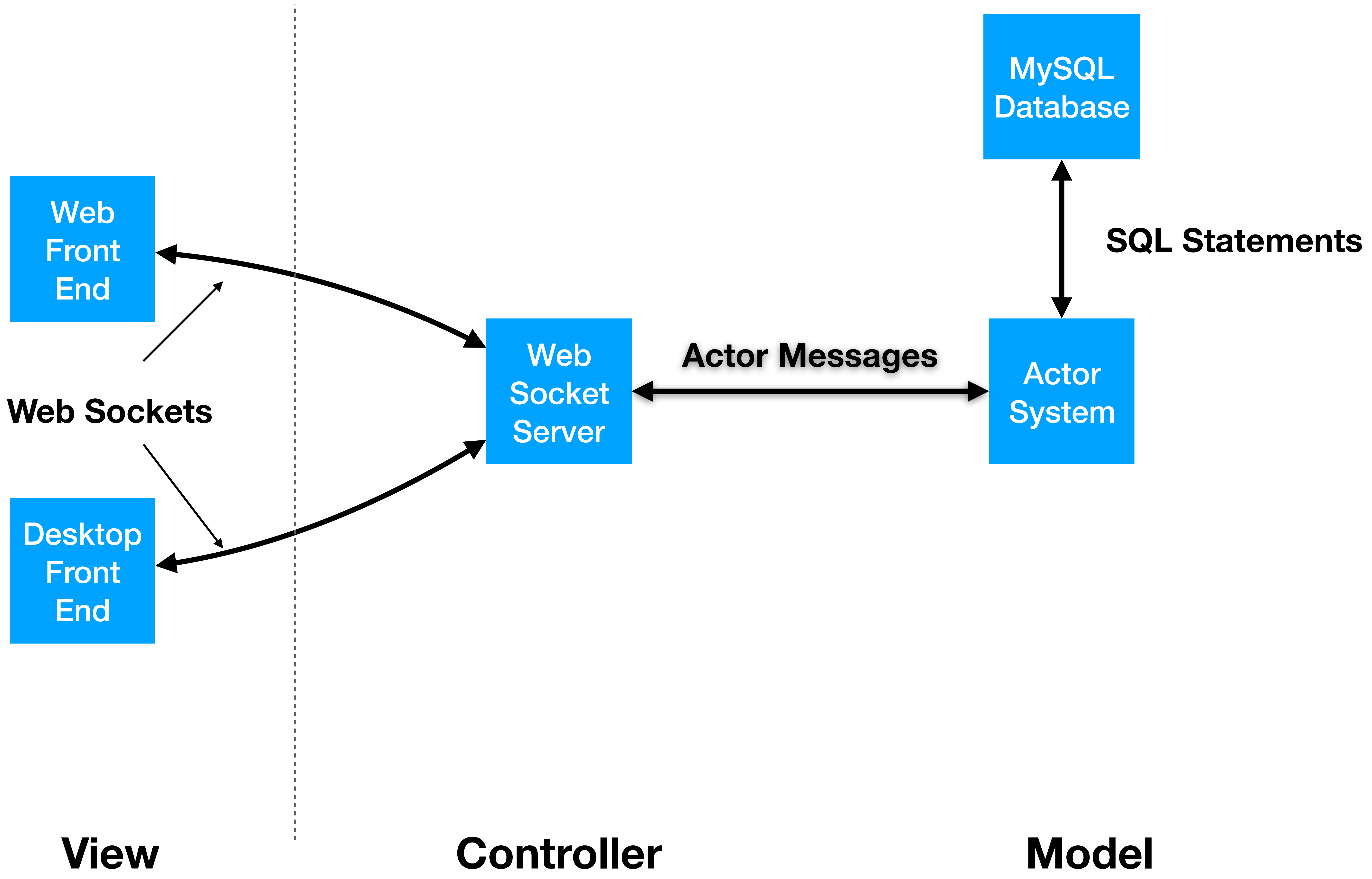
Lecture Question

Complete the MVC structures chat app in the examples repository

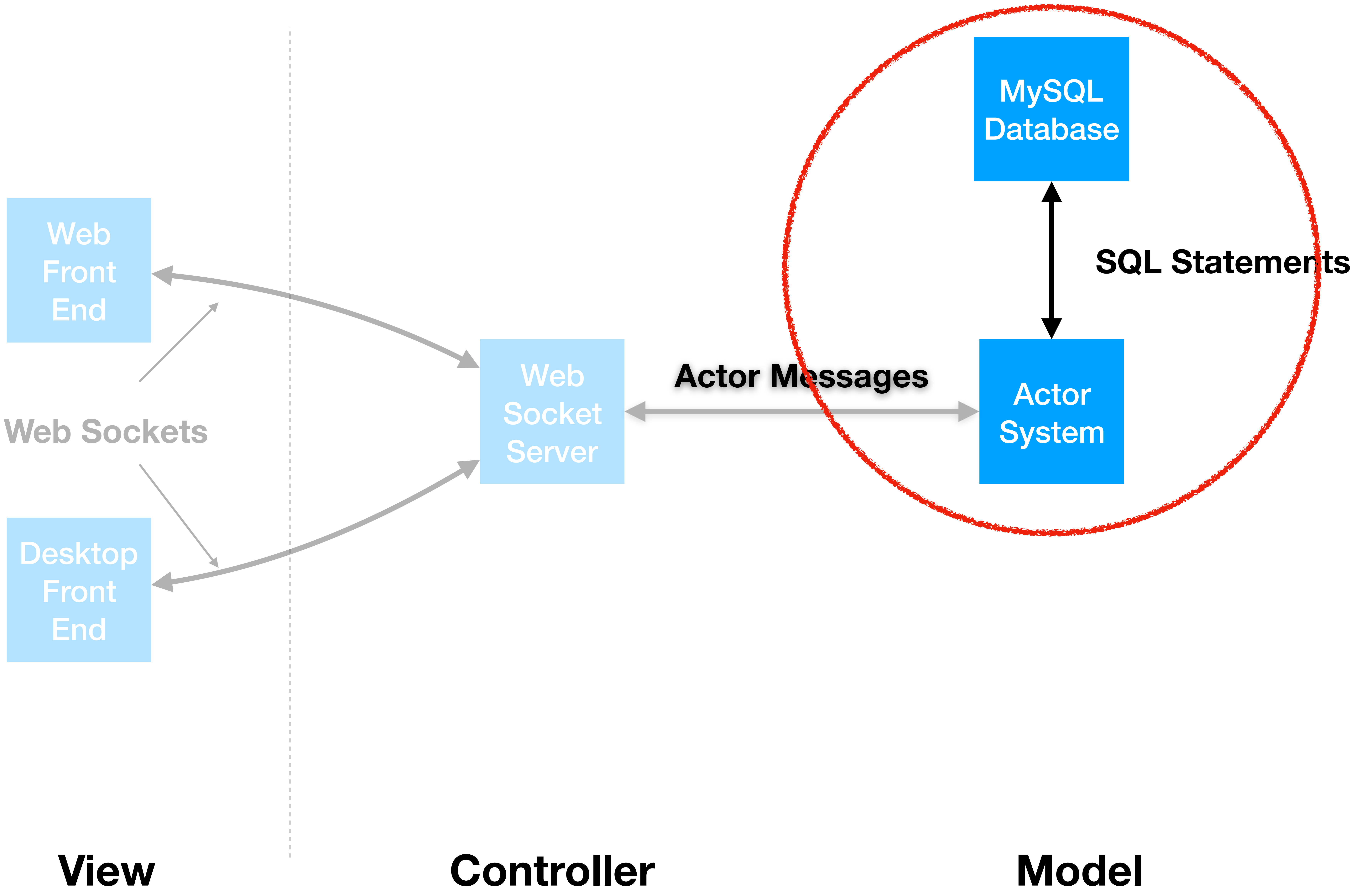
- In the CSE116-Examples repo, find the package named mvc with classes Model, View, and Controller
- This is the start of a chat app with no functionality. Your task is to complete it
- Model API (You must implement these methods)
    - sendMessage(String): Unit
        - Called when a/the user sends a message
    - allMessages(): List[String]
        - Returns all sent messages (order doesn't matter for testing)
- Controller (You must implement the handle method)
    - Action event handler called when the user clicks the send button
    - Contains references to the text typed by the user and the model
- View (Do not edit the view)
    - Displays GUI elements to the user and calls allMessages() to display latest data

Databases

MMO Architecture



MMO Architecture



MySQL v. SQLite

- MySQL
  - Database server
  - Runs as a separate process that could be running on a different machine
  - Connect to the server and send it SQL statements to execute
- SQLite
  - Removes networking
  - Must run on the same machine as the app
  - Can be used for small apps
    - Common in embedded system - Including Android/iOS apps

MySQL

- A program that must be downloaded, installed, and ran
- Is a server
  - By default, listens on port 3306
- Connect using JDBC (Java DataBase Connectivity)
  - Must download the MySQL Driver for JDBC (Use Maven. Artifact in repo)
  - JDBC abstracts out the networking so we can focus on the SQL statements

MySQL

- After MySQL is running and the JDBC Driver is downloaded..
- Connect to MySQL Server by providing
  - url of database
  - username/password for the database
    - Whatever you chose when setting up the database

```
val url = "jdbc:mysql://localhost/mysql?serverTimezone=UTC"
val username = "root"
val password = "12345678"

var connection: Connection = DriverManager.getConnection(url, username, password)
```

MySQL - Security

- For real apps that you deploy
  - Do not check your password into version control!
    - A plain text password in public GitHub repo is bad
    - Attacker can replace localhost with the IP for your app and can access all your data
  - Common to save the password in a environment variable to prevent accidentally pushing it to git
  - Do not use the default password for any servers you're running
    - This is what caused the Equifax leak (Not with MySQL)
- Attacker have bots that scan random IPs for such vulnerabilities

```
val url = "jdbc:mysql://localhost/mysql?serverTimezone=UTC"
val username = "root"
val password = "12345678"

var connection: Connection = DriverManager.getConnection(url, username, password)
```

MySQL

- Once connected we can send SQL statements to the server

```
val statement = connection.createStatement()
statement.execute("CREATE TABLE IF NOT EXISTS players (username TEXT, points INT)")
```

- If using inputs from the user, always use prepared statements
    - Indices start at 1 😢

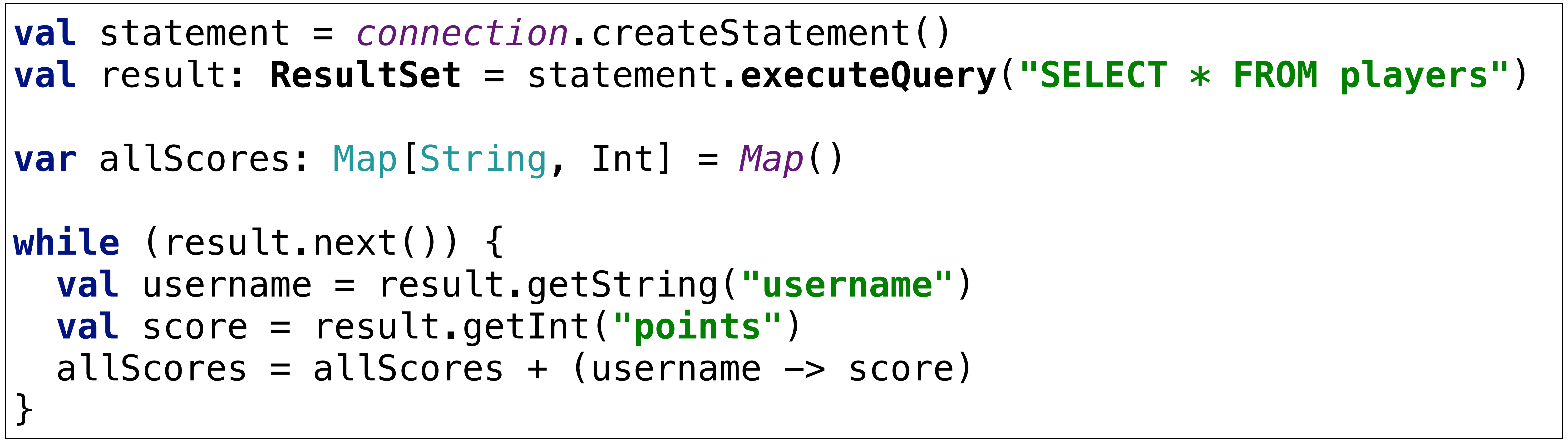
```
val statement = connection.prepareStatement("INSERT INTO players VALUE (?, ?)")

statement.setString(1, "mario")
statement.setInt(2, 10)

statement.execute()
```

MySQL - Security

- Not using prepared statements?
  - Vulnerable to SQL injection attacks
- If you concatenate user inputs directly into your SQL statements
  - Attacker chooses a username of "';DROP TABLE players;"
  - You lose all your data
  - Even worse, they find a way to access the entire database and steal other users' data
  - SQL Injection is the most common successful attack

MySQL

- Use executeQuery when pulling data from the database
- Returns a ResultSet
  - The next() methods queue the next result of the query
  - next returns false if there are no more results to read
- Can read values by index of by column name
  - Use get methods to convert SQL types to Scala types



```
val statement = connection.createStatement()
val result: ResultSet = statement.executeQuery("SELECT * FROM players")

var allScores: Map[String, Int] = Map()

while (result.next()) {
  val username = result.getString("username")
  val score = result.getInt("points")
  allScores = allScores + (username -> score)
}
```

SQL

- SQL is based on tables with rows and column
  - Similar in structure to CSV except the values have types other than string
- How do we store an array or key-value store?
  - With CSV our answer was to move on to JSON
  - SQL answer is to create a separate table and use JOINs (Or move to MongoDB)
  - This is beyond CSE116 so we'll stick to data that fits the row/column structure

MySQL

- No automated testing of MySQL in this course

- Fair warning:
    - You will use MySQL in the next lab activity (After demo 2)
    - Have MySQL installed, running, and tested before that lab so you have enough time to complete the activity