What we're learning

1. Stateful vs Stateless Backends
2. State management in a Backned app
3. Singleton Pattern
4. Pub Subs + Singleton pattern

Stateful vs Stateless Backends

Common interview question

Stateless servers

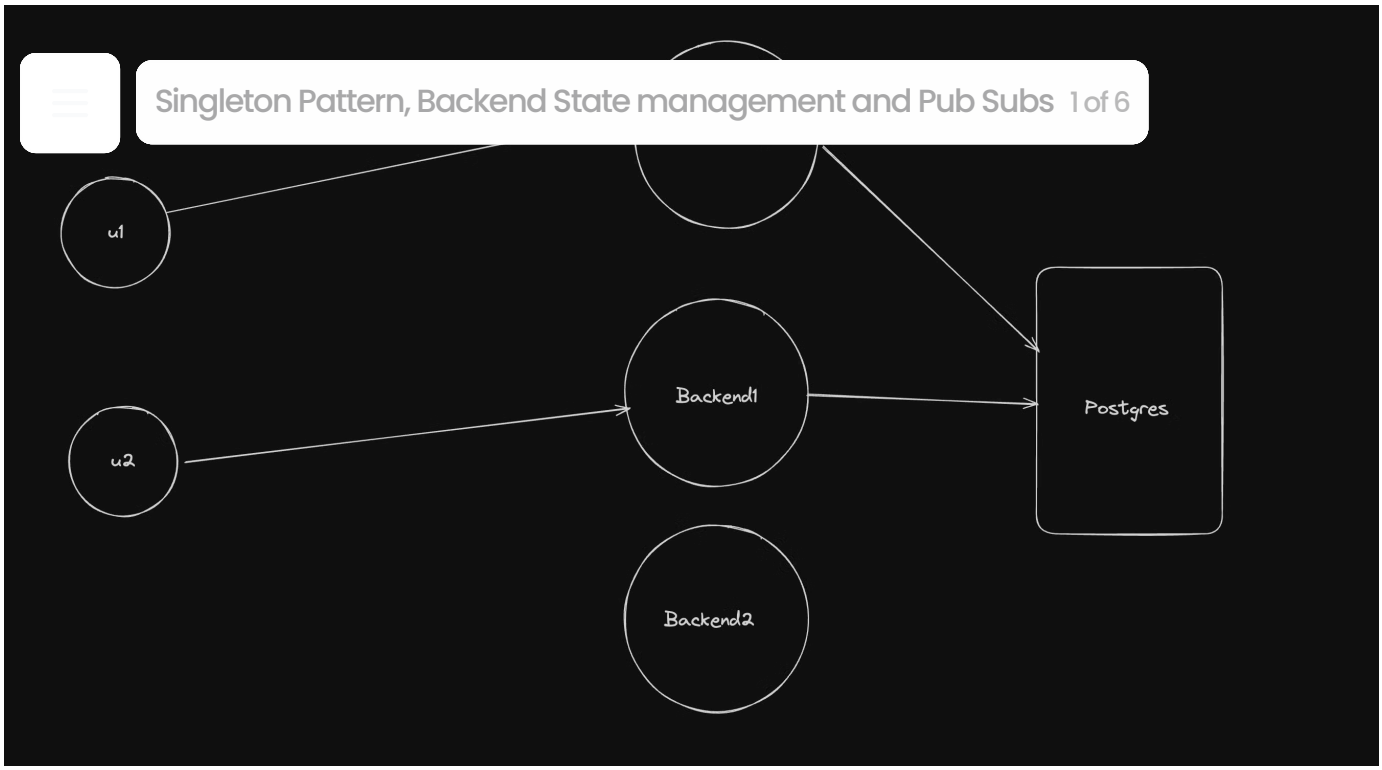
Usually when you write HTTP servers, they dont hold any state

This means, they don't have any in memory variables that they use

They usually rely on the database for state

Advantages

1. Users can connect to a random server, there is no need of stickiness
2. Can autoscale up and down easily and simply decide where to route traffic based on CPU usage.



Stateful servers

A lot of times, you make servers hold state

Good examples of this are

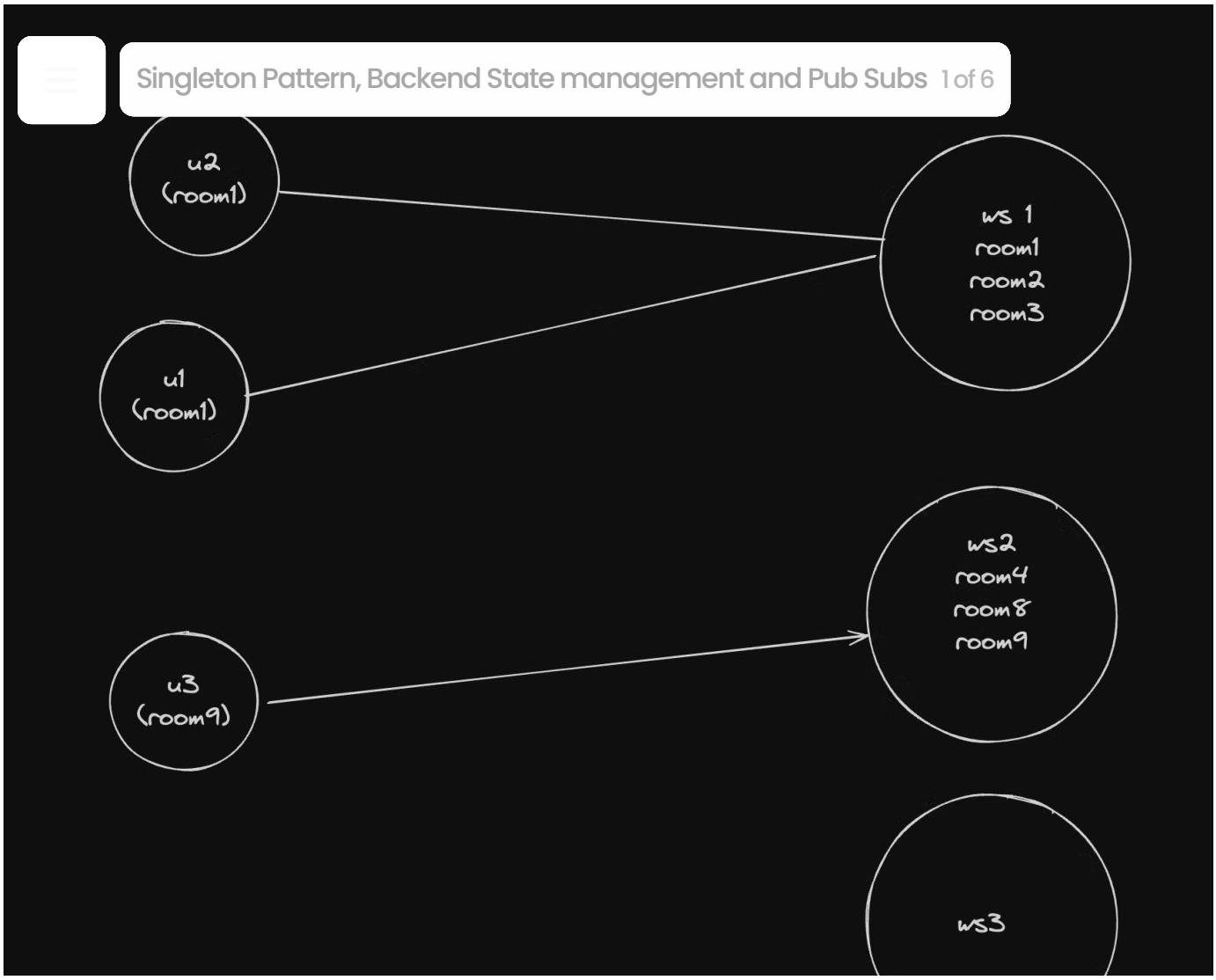
1. Creating an in memory cache - https://github.com/code100x/cms/blob/e905c71eacf9d99f68db802b24b7b3a924ae27f1/src/db/Cache.ts#L3
2. Storing the state of a Game in case of a realtime game - https://github.com/code100x/chess/blob/main/apps/ws/src/Game.ts#L41-L47
3. Storing a list of 10 most latest chats in memory for a chat application

In case 1 , there is no need of stickiness

In case of 2 and 3 , there is need of stickiness

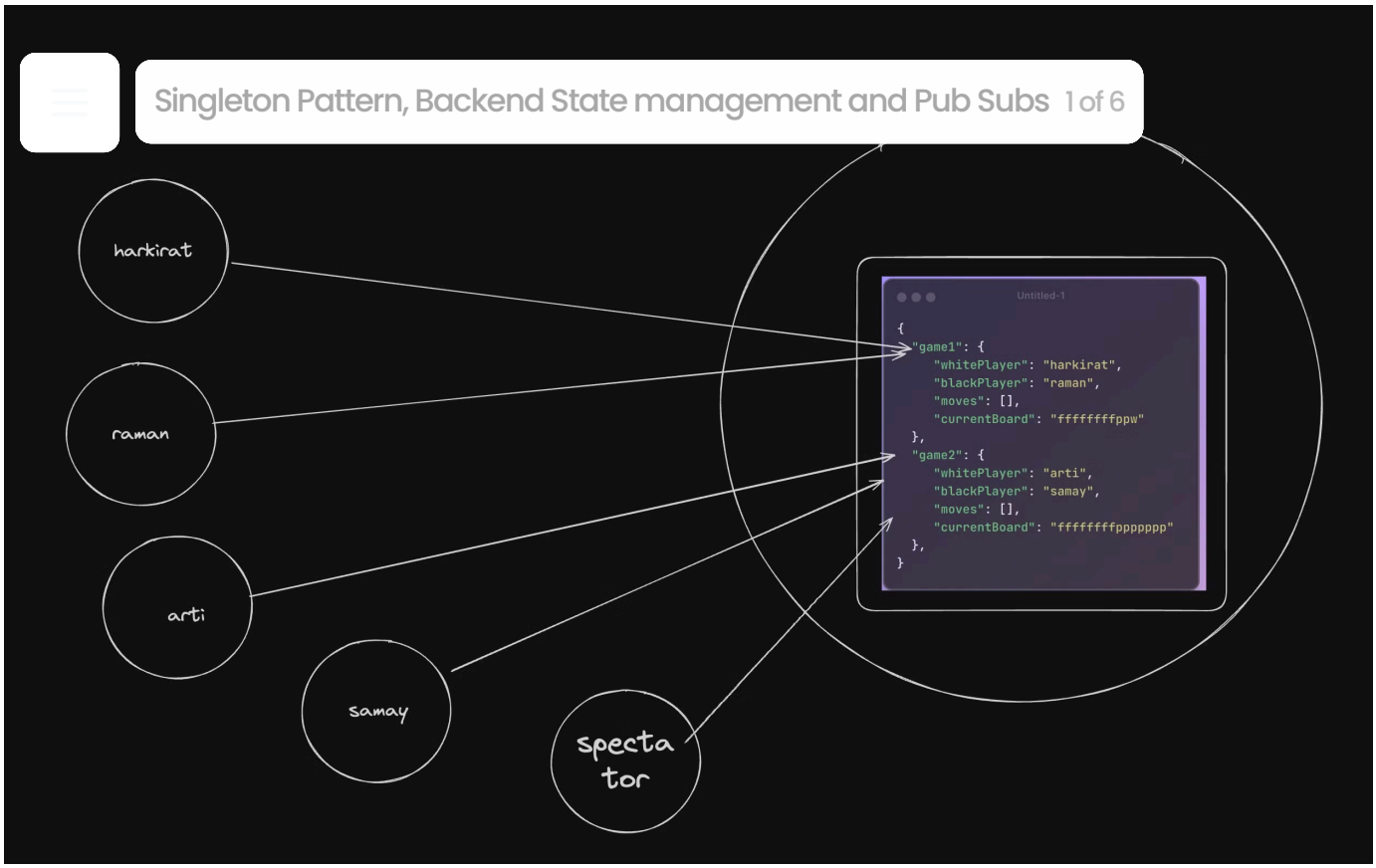
Stickiness

Making sure that a user who is connected in a specific room, gets connected to a specific server.



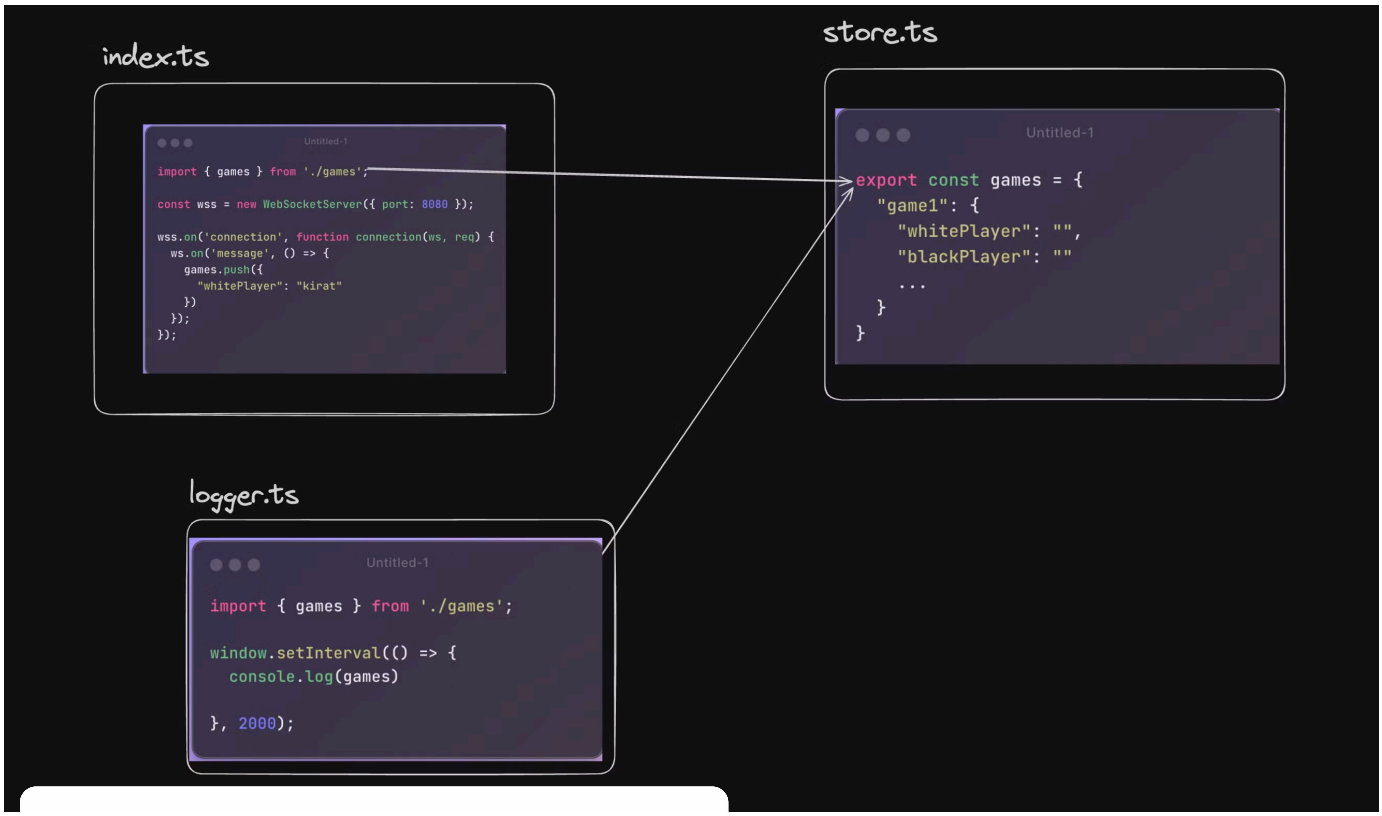
State in JS process

How/where can you store state in a Javascript process



This state might being used by multiple files, not just one, so the following approach might not work

Lets try the following -



- index.ts - pushes to games array


```
import { games } from "./store";
import { startLogger } from "./logger";

startLogger();

setInterval(() => {
    games.push({
        "whitePlayer": "harkirat",
        "blackPlayer": "jaskirat",
        moves: []
    })
}, 5000)
```

- logger.ts - uses the games array

```
import { games } from "./store";

export function startLogger() {
    setInterval(() => {
        console.log(games);
    }, 4000)
}
```

- store.ts - Exports the game array

```
interface Game {
    whitePlayer: string;
    blackPlayer: string;
    moves: string[];
}

export const games: Game[] = [];
```

This will work, but a lot of times you need to attach functionality to `state` as well.

Let's see how can we create a class called `GameManager` and expose some

pattern

Let's create a class that

1. Stores games
2. Exposes functions that let you mutate the state

```
interface Game {
    id: string;
    whitePlayer: string;
    blackPlayer: string;
    moves: string[];
}

export class GameManager {
    private games: Game[] = [];

    public addGame(game: Game) {
        this.games.push(game);
    }

    public getGames() {
        return this.games;
    }

    // e5e7
    public addMove(gameId: string, move: string) {
        const game = this.games.find(game => game.id === gameId);
        if (game) {
            game.moves.push(move);
        }
    }

    public logState() {
        console.log(this.games);
    }
```

Bad approach

Create separate instance of GameManager in every file that needs it

▼ GameManager.ts

```ts
interface Game {
  id: string;
  whitePlayer: string;
  blackPlayer: string;
  moves: string[];
}

export class GameManager {
  private games: Game[] = [];

  public addGame(game: Game) {
    this.games.push(game);
  }

  public getGames() {
    return this.games;
  }

  // e5e7
  public addMove(gameId: string, move: string) {
    const game = this.games.find(game => game.id === gameId);
    if (game) {
      game.moves.push(move);
    }
  }
}
```

▼ logger.ts

```ts
import { GameManager } from "./GameManager";

const gameManager = new GameManager();

export function startLogger() {
  setInterval(() => {
    gameManager.logState();
```

```
    }, 4000)
}
```


▼ index.ts

```
import { GameManager } from "./GameManager";
import { startLogger } from "./logger";

const gameManager = new GameManager();

startLogger();

setInterval(() => {
    gameManager.addGame({
        id: Math.random().toString(),
        "whitePlayer": "harkirat",
        "blackPlayer": "jaskirat",
        moves: []
    })
}, 5000)
```

Slightly Better approach

Export a single instance of `gameManager` from `GameManager.ts` and use it everywhere

Even better approach - Singleton Pattern

Completely prevent any developer from ever creating a new instance of the `GameManager` class

Static attributes -

In JavaScript, the keyword **static** is used in classes to declare static methods or static properties. Static methods and properties belong to the class itself, rather than to any specific instance of the class. Here's a

▼ Example of a class with static attributes

```
class Example {
  Singleton Pattern, Backend State management and Pub Subs 1 of 6

    constructor() {
      Example.count++;  // Increment the static property using the class nam
    }
  }

  let ex1 = new Example();
  let ex2 = new Example();
  console.log(Example.count);  // Outputs: 2
```

```
interface Game {
  id: string;
  whitePlayer: string;
  blackPlayer: string;
  moves: string[];
}

export class GameManager {
  private static instance: GameManager; // Create a static instance of the cla
  private games: Game[] = [];

  private constructor() {
    // Private constructor ensures that a new instance cannot be created fron
  }

  public static getInstance(): GameManager {
    if (!GameManager.instance) {
      GameManager.instance = new GameManager();
    }
    return GameManager.instance;
  }
  // ... other methods
}

// Usage GameManager.getInstance().addGame()
```

GameManager.ts

Singleton Pattern, Backend State management and Pub Subs 1 of 6

```
    id: string;
    whitePlayer: string;
    blackPlayer: string;
    moves: string[];
}

export class GameManager {
    private static instance: GameManager; // Create a static instance of the
    private games: Game[] = [];

    private constructor() {
        // Private constructor ensures that a new instance cannot be created f
    }

    public static getInstance(): GameManager {
        if (!GameManager.instance) {
            GameManager.instance = new GameManager();
        }
        return GameManager.instance;
    }

    public addGame(game: Game) {
        this.games.push(game);
    }

    public getGames() {
        return this.games;
    }

    public addMove(gameId: string, move: string) {
        const game = this.games.find(game => game.id === gameId);
        if (game) {
            game.moves.push(move);
        }
    }

    public logState() {
        console.log(this.games);
```

```
    }
}
```


▼ logger.ts

```
import { GameManager } from "./GameManager";

export function startLogger() {
    setInterval(() => {
        GameManager.getInstance().logState();
    }, 4000)
}
```

▼ index.ts

```
import { GameManager } from "./GameManager";
import { startLogger } from "./logger";

startLogger();

setInterval(() => {
    GameManager.getInstance().addGame({
        id: Math.random().toString(),
        "whitePlayer": "harkirat",
        "blackPlayer": "jaskirat",
        moves: []
    })
}, 5000)
```

Try creating a new instance of the `GameManager` class. Notice it wont let you.

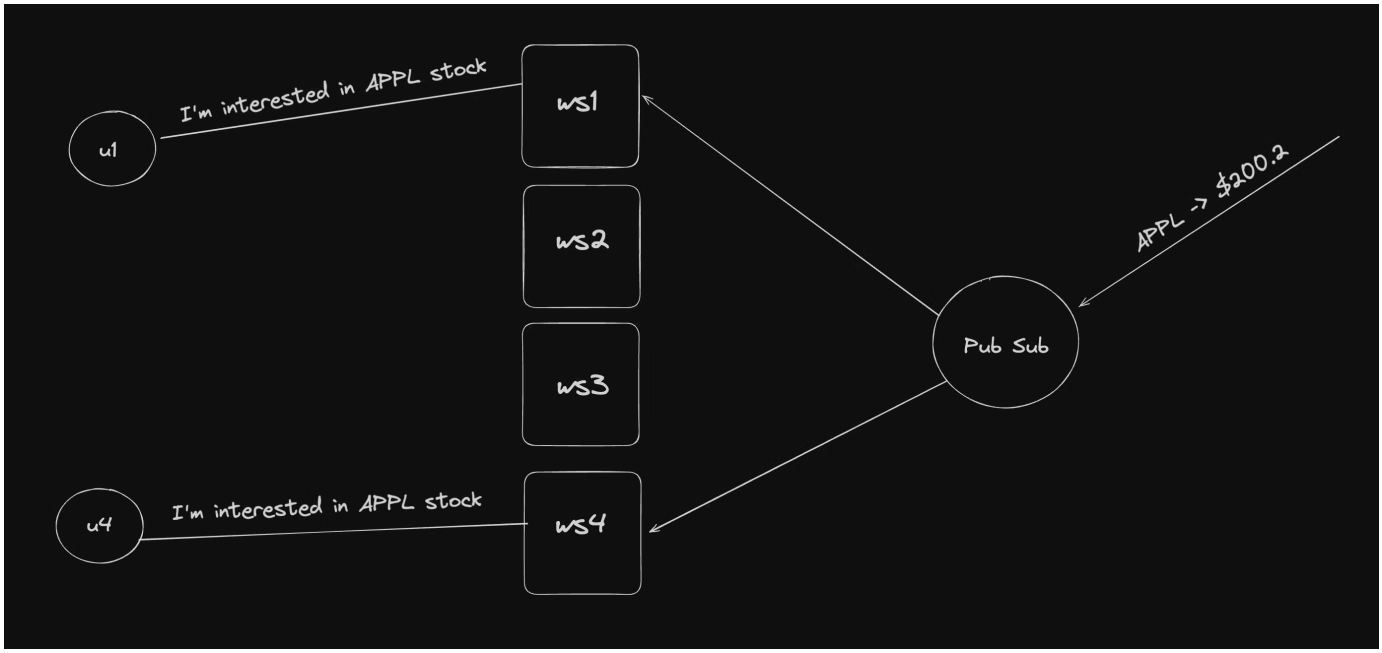
Pub Sub + Singleton

Singleton Pattern, Backend State management and Pub Subs 1 of 6

What if You want to create a system where users can subscribe to the feed of stocks (prices)

This application will be used by >1Mn users

How would you build it?



- Create a PubSubManager class (singleton)
- It keeps track of what all stocks are users on this server interested in
- It tells the pub sub whenever a new stock is added or a stock is removed from the list of interested stocks on that server
- It relays the events to the right sockets whenever an event is received

Singleton Pattern, Backend State management and Pub Subs 1 of 6

(Implementation)

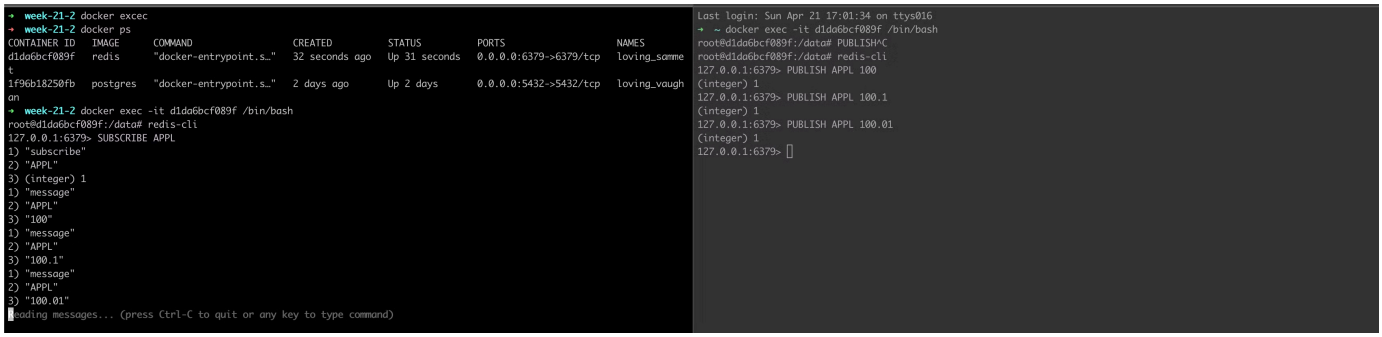
Starting the pub sub

- Start a pub sub (redis is a decent one)

```
docker run -d -p 6379:6379 redis
```

- Try a simple publish subscribe in two terminals

```
docker exec -it d1da6bcf089f /bin/bash
redis-cli
```



Creating the PubSubManager

- Init a simple node.js project

```
npm init -y
npx tsc --init
npm install redis
```

▼ Create the Pub Sub Manager

```
// Import the necessary module from the 'redis' package
import { createClient, RedisClientType } from 'redis';
```

```
export class PubSubManager {
  private static instance: PubSubManager;
  private redisClient: RedisClientType;
  private subscriptions: Map<string, string[]>;

  // Private constructor to prevent direct construction calls with the `new` o
  private constructor() {
    // Create a Redis client and connect to the Redis server
    this.redisClient = createClient();
    this.redisClient.connect();
    this.subscriptions = new Map();
  }

  // The static method that controls the access to the singleton instance
  public static getInstance(): PubSubManager {
    if (!PubSubManager.instance) {
      PubSubManager.instance = new PubSubManager();
    }
    return PubSubManager.instance;
  }

  public userSubscribe(userId: string, stock: string) {
    if (!this.subscriptions.has(stock)) {
      this.subscriptions.set(stock, []);
    }
    this.subscriptions.get(stock)?.push(userId);

    if (this.subscriptions.get(stock)?.length === 1) {
      this.redisClient.subscribe(stock, (message) => {
        this.handleMessage(stock, message);
      });
      console.log(`Subscribed to Redis channel: ${stock}`);
    }
  }


  public userUnSubscribe(userId: string, stock: string) {
    this.subscriptions.set(stock, this.subscriptions.get(stock)?.filter((sub) =

    if (this.subscriptions.get(stock)?.length === 0) {
      this.redisClient.unsubscribe(stock);
      console.log(`Unsubscribed to Redis channel: ${stock}`);
    }
```

```
    }
```



```
    private handleMessage(stock: string, message: string) {
        console.log(`Message received on channel ${stock}: ${message}`);
        this.subscriptions.get(stock)?.forEach((sub) => {
            console.log(`Sending message to user: ${sub}`);
        });
    }

    // Cleanup on instance destruction
    public async disconnect() {
        await this.redisClient.quit();
    }
}
```

▼ Create a simple index.ts file to simulate users

```
import { PubSubManager } from "./PubSubManager";

setInterval(() => {
    PubSubManager.getInstance().userSubscribe(Math.random().toString(),
}, 5000)
```