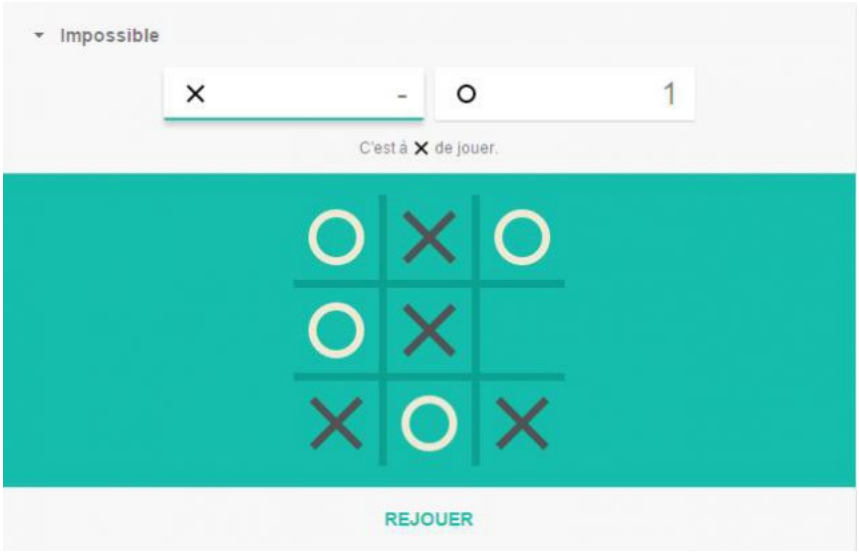
01 - Design Tic-Tac-Toe - Answers

What is Tic-Tac-Toe?

TicTacToe is a 2 player game played on a 3 x 3 board. Each player is allotted a symbol (one X and one O). Initially, the board is empty. Alternatively, each player takes a turn and puts their symbol at any empty slot. The first player to get their symbol over a complete row OR a complete column OR a diagonal wins.
You can play the game within Google Search by just searching for “tictactoe”!



Questions to Ask

- Will the game be played amongst only 2 players or can there be any number of players in future?
- Is the board size restricted to 3x3 or can it be any NxN?
- Can there be different ways to win?
- Can one of the players be a bot?
- Feature Suggestions:
    - Do we want to time a move? Skip/ Declare the other person as winner if the move doesn’t happen within x seconds.
    - Do we want to support undo operation?
    - Can there be some players who are just watching? Not playing.

    - Do we want to store analytics? Basically previous games, who played what move etc.
    - Support for tournaments? Basically a set of matches, each match between 2 players of the tournament.

Expectations

- The code should be working and functionally correct
- Good software design practices should be followed:
- Code should be modular, readable, extensible
- Separation of concern should be addressed
- Project structured well across multiple files/ packages
- Write unit tests
- No need of GUI

Problem Requirements

- Board can be of any NxN size.
- There can be two players.
- Each player will be allotted a symbol.
- The symbol can be one of O and X.
- The players can be either humans or bots.
- Each human player will have a name, email and profile image.
- Each bot player will have a difficulty level.
- Any random player can start the game.
- Then the players will take turns alternatively.
- The player with any consecutive N symbols in a row, column or diagonal wins.
- If the board is full and no player has won, the game is a draw.

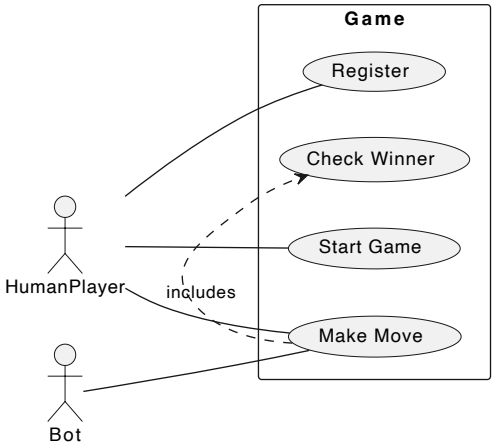
Entities and their attributes

- Game
    - Board
    - Players
- Board

    - Cells
- Cell
    - Row
    - Column
    - Symbol
- Human Player
    - Name
    - Email
    - Profile Image
- Bot Player
    - Difficulty Level

Design

Use Case Diagram



API or CLI Design

The usecase diagram gives us a good idea of the API design. We can have the following APIs:

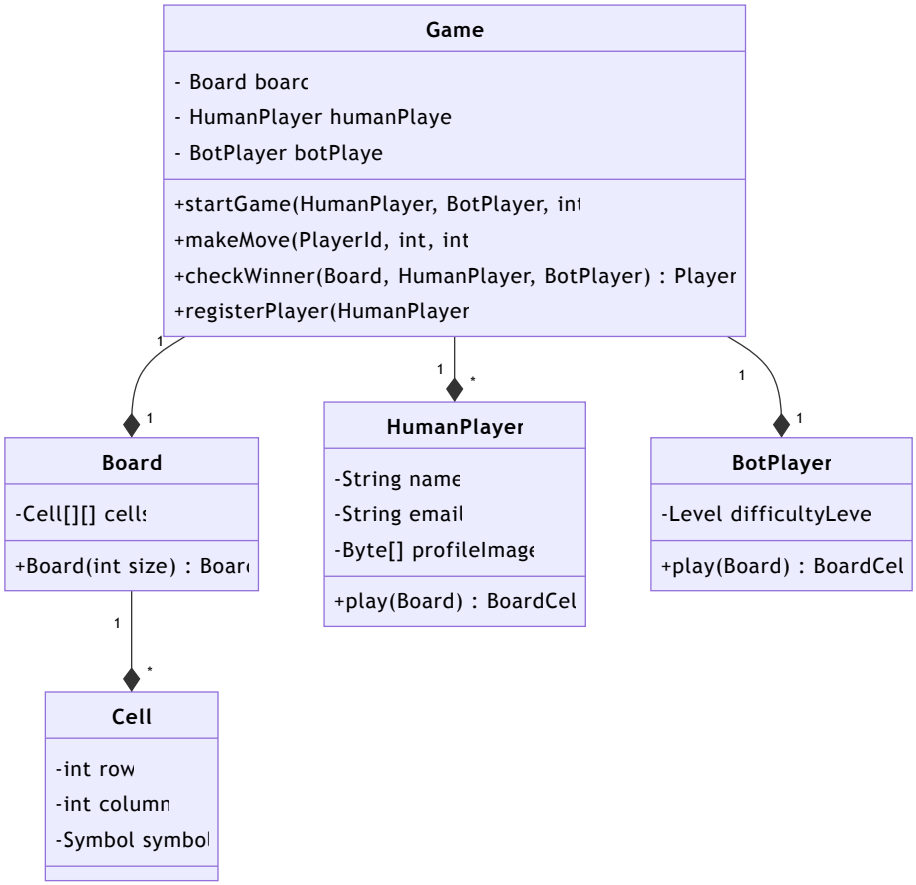
- Register a player
    - `API - POST /register - {"name": "Paul Morphy", "email": "blind@chess.in", ...}`
    - `CLI - tictactoe register --name <name> --email <email> --profile-image <profile-image>`
- Start a game
    - `API - POST /game/start - {"player1": "paul", "player2": "bot", "board-size": 3}`

    - CLI - `tictactoe start --player1 <player1> --player2 <player2> --board-size <board-size>`

- Make a move
    - API - `POST /game/move - {"player": "paul", "row": 1, "column": 2}`
    - CLI - `tictactoe move --player <player> --row <row> --column <column>`

Class Diagram

INITIAL DESIGN

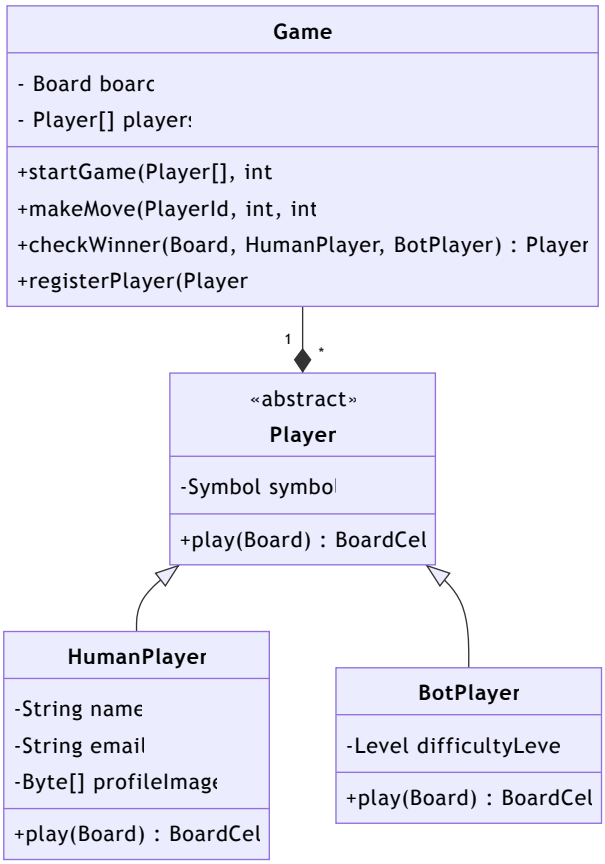


Problems:

- The Game class is tightly coupled with the HumanPlayer and BotPlayer classes. It is not extensible to support any other type of player and number of players.
- There is no common contract for the players.
- `Huge memory consumption` - A player can play multiple games at the same time. Each will have a new `HumanPlayer` object. Each player object will have the profile image. This will consume a lot of memory.

- Implementing the `play` method for the bot player will lead to SRP and OCP violations because it will be deciding the move based on the difficulty level. This will lead to a lot of if-else conditions.

ADDING A CONTRACT FOR PLAYERS USING AN ABSTRACT CLASS



Problems so far:

- ~~The Game class is tightly coupled with the IHumanPlayer and BotPlayer classes. It is not extensible to support any other type of player and number of players.~~
- ~~There is no common contract for the players.~~
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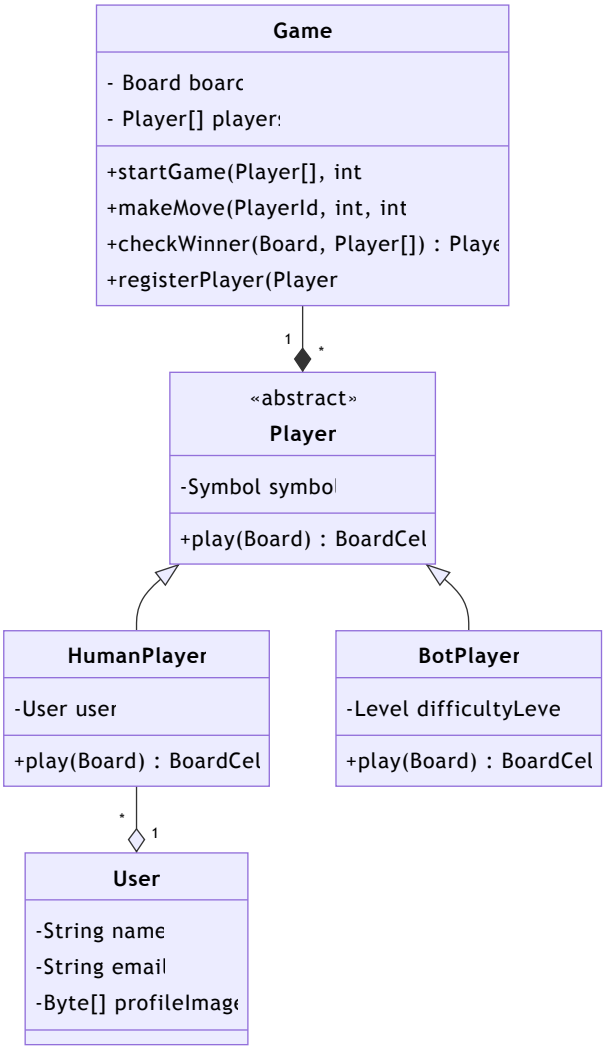
Solving the memory consumption problem using Flyweight pattern



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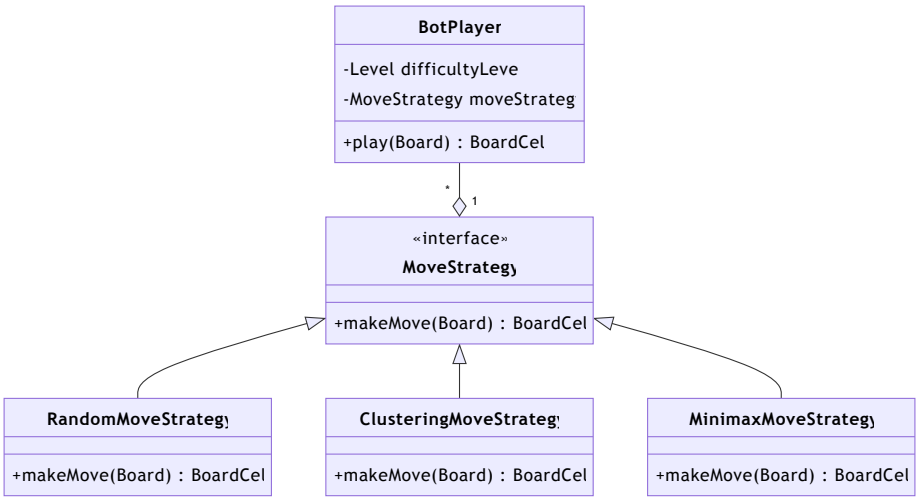
Fixing the SRP and OCP violations using Strategy pattern



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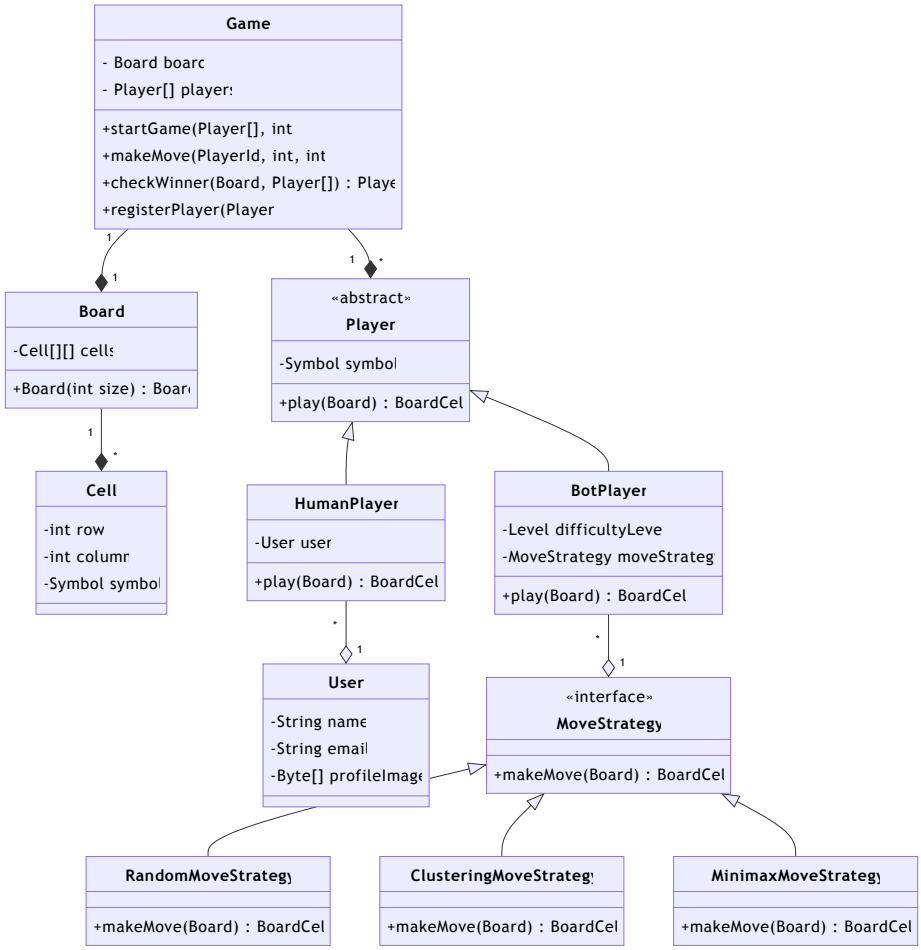
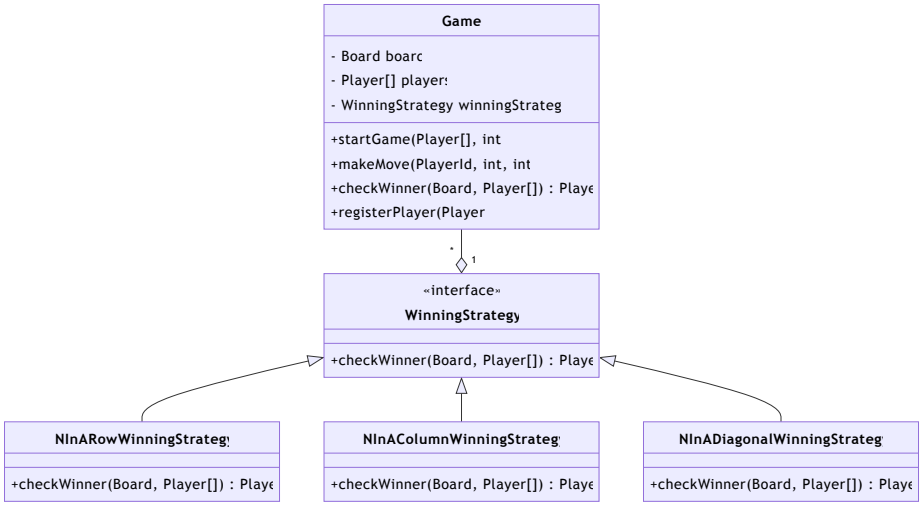
Complete Class Diagram



Future requirement - Different winning conditions for different number of players

- We want to support different winning conditions for different number of players.
- Games can same winning conditions for different number of players and different winning conditions for same number of players.
- Solution - Use a strategy pattern to decide the winning condition for a game.



Side assignment

- A common requirement in games is to undo the last move. How would you design your system to support this requirement?