# Technical Plan

## Balancer

Final Project for CS-C2120

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# Contents

# 1 Class Structure

## 1.1 Game and GameObject

The Game class will store the game state (players, scales, weights, . . . ) in the a hash map **gameObjects**. It also have a FileManager that manage the process of saving and loading game state from a file.

## 1.2 Player

Player is a **sealed abstract** class which models a player in the game, with two **case class** *Bot* and *Human*.

The *player_code* attribute is a character (ex. "a", "b", "c", ....) that represents player's weights in the text-based version of the game. The **score** attribute will be dynamically calculated.

## 1.3 Grid, GridCell and GridObject

The game objects, i.e weights and scales, are displayed on a grid. There is a grid instance in the Game class and this will be interpreted by different renderer (*GraphicManager* and *ConsoleManager*) to be display on the screen.

Each weight occupies only 1 GridCell while each scale occupies many.

Each GridObject has a buffer that contains all the GridCell that they lie upon. GridObject also has an anchor that signify the center of the shape. For a weight, it just the single cell that it occupies, for a scale, it is the center of the board.

## 1.4 Weight, Scale and Stack

The classes Weight, Stack, Scale model a single weight, a stack of weights and a scale respectively. Stack and Scale is derived from Weight, thus they also have an owner, mass and height. *(Noted: height is only used in the algorithm displaying these objects on the grid)*

The base Weight class and its derived classes Stack and Scale also have the **parent** attribute, which store a reference to its parent.

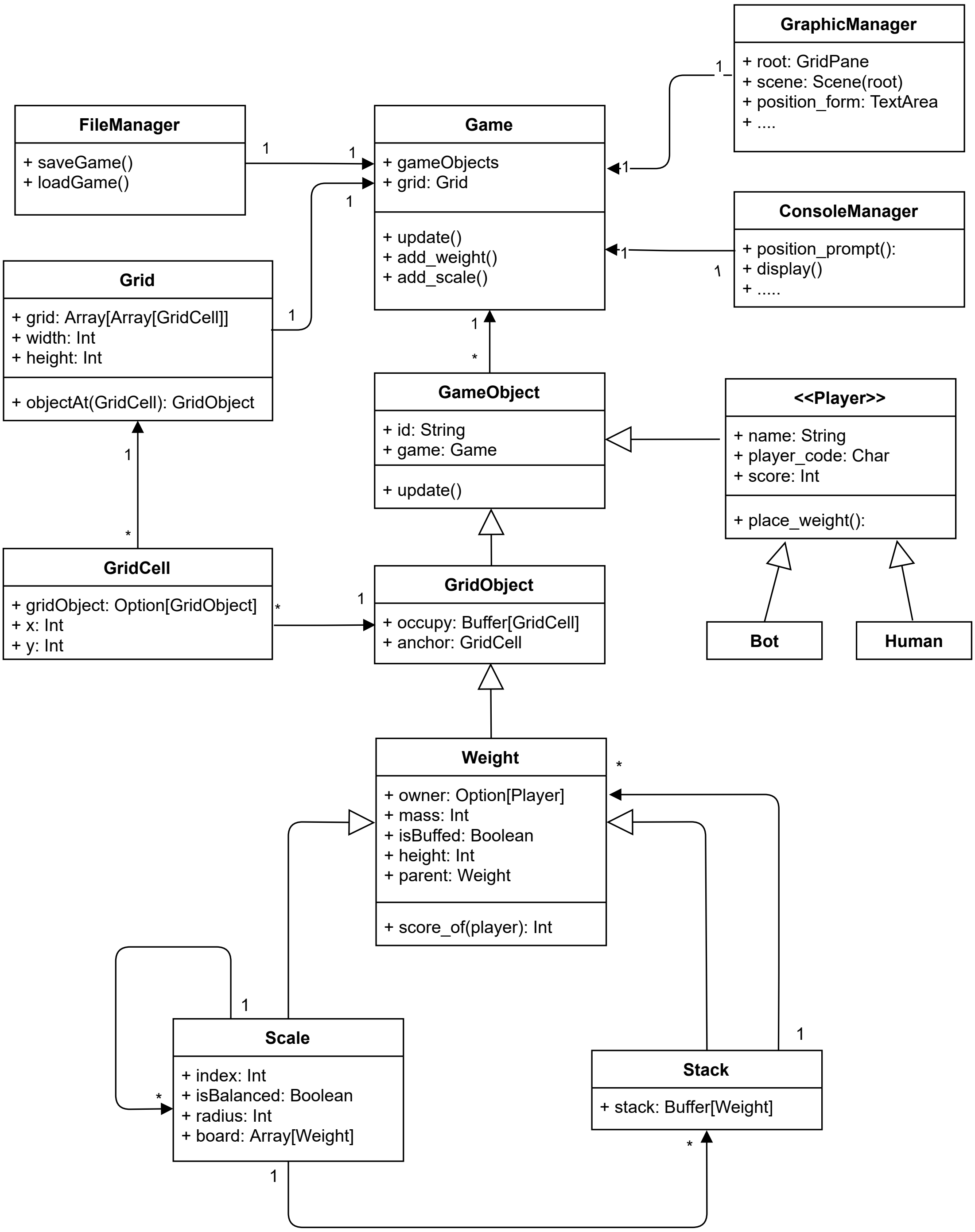
## 1.5 GraphicManager and ConsoleManager

These two class will interpret the grid in the Game class and display it to the user, graphically in a window or text-only on the console.

GraphicManager also has UI elements such as TextArea and Button to prompt for user input using ScalaFx. Both will update the game state by adding weight to the gameObjects hash map.

"Core" functions in the Game class such as *add_weight* and *add_scale* will be used to automate this process.

Figure 1: UML Diagram for class structure



# 2 Use Case Description

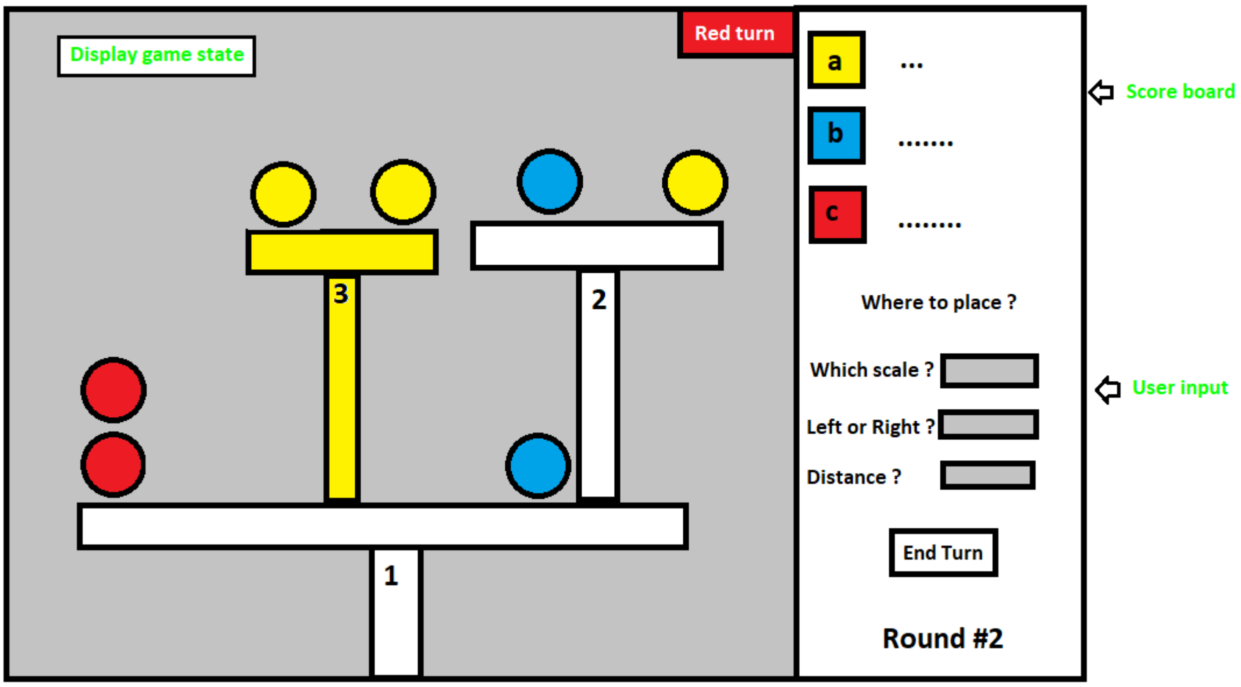
## 2.1 Graphical

The game starts and presents the **Menu scene** on the window, where user(s) can use their mouse to click on one of three button: "Start new game", "Load saved game", or "Quit" *(Notes: a "Setting" button and "Setting Scene" might be added, where users can modify the configuration file graphically)*

Clicking one of the three button will trigger the GraphicManager to switch to a different scenes.

### 2.1.1 Start New Game

Clicking the "Start new game" button will lead to the **Setup Scene** being shown where user(s) will first enter the number of players, then one at the time, a pop-up form will show up asking for each user's name, and a tick box to determine whether this player is a bot or not. This is handled by the GraphicManager. When finished, user(s) will be shown the **Game Scene** where user(s) spends most of the time interacting with the game. The **Game Scene** was the drafted user interface in the General Plan of this project:



The left gray region is where the player can move around, zoom in and out to see which scales and weights is owned by whom and how they are placed. This will be handled by a **Camera** and the GraphicManager.

The right white region is the main UI. The top part is the score board where more information about the current state of the game is shown, for example each player's score, the number of weights left,.... The information/text in ther scoreboard will be binded directly to the game state and will update immediately when the game state changes. The middle part is a form where player in his/her turn can fill in and trigger the game to place the weight accordingly. The "End turn" button will "call back" to the *place_ weight()* in the Player class to place the weight.

At the end of the round, a pop-up will be shown and announce the round's winner. The game then continues to the next round, randomly placing some weights and a scale. If there is no round left, a pop-up will announce the game 's winner instead.

#### 2.1.2 Load Saved Game

User(s) can also load previous state of the game from a saved file by clicking the "Load Saved Game" button. The structure of the saved file is detailed in the File and Format Section of the General Plan. Handling saving and loading game state from file is done by the FileManager class, separated from main Game class.

The "Quit" button simply ends the program.

### 2.2 Text-on-console

The program can be run on the command line with no parameter to start a new game or with a path to the save file to resume previous games. *Notes: This might change in the future where user can pick in the game instead*

#### 2.2.1 New Game

When a brand new game starts, it will prompt the user to enter some basic information about the players, e.g, how many of them are there, their names, . . . . Then the first round starts and each player will one at a time be prompted for information on where his/her weight should be placed. The current score of each players, the state of the game will also be shown to each players for them to make a decision.

When a round finished, the winner of that round will be announced. At the end of the game, the overall winner will be announced instead.

#### 2.2.2 Load Game

When the save file is loaded successfully, the game will continue from the state when it is saved. Otherwise, it will print out the line causing the failure and exit.

## 3 Algorithms

Most components in the game requires some forms of algorithm/recursion and mathematics to achieve its functionality:

- Mass of an object the *mass* attribute will be called recursively, summing the mass of all the objects it contains.

- Height of an object: the *height* attribute of a scale will be called recursively, which is the **max** height of all the scales and stacks it contains. For a stack, it just the number of its weights.
- Checking whether the scale is balance: After having the mass of all the objects on the parent scale, we can calculate its imbalance. The formula is as follow:

$$Imbalance = \sum_{i=-r}^{r} i\ m_i$$

  where $r$ is the radius of the scale, $m_i$ is the mass of the object at distance $|i|$ from the center. Negative value of $i$ indicates the object is on the left arm of the scale.
- Score of a player: the score of player $p$ on an **object** $o$ is a recursive piecewise function conditioned by $o$ and $p$:

$$s(o,p) = \begin{cases} s(o,p) = \sum_{i=-r}^{r} |i|\ s(o_i,p), & \text{if } o \text{ is a scale} \\ s(o,p) = \sum_{w \in S} s(w,p), & \text{if } o \text{ is a stack, with weights } S \\ s(o,p) = 1 & \text{if } o \text{ is a weight owned by } p \\ s(o,p) = 0 & \text{if } o \text{ is a weight not owned by } p \end{cases}$$

  where $o_i$ is the object at distance $|i|$ from the center the scale. Negative value of $i$ indicates the object is on the left arm.
- Intelligent bot: the bot will use a recursive algorithm to traverse each scale, searching for all possible best moves that maximize its score gain in its turn and randomly picks one (or if there is only one best move, picked it). *Notes: Computing time is nearly instant for most game with human players, which should be at most 5-6 scales per round.*

# 4 Data Structures

The **gameObjects** will server as an indexer/register for all GameObject instances, whether it is a player, scale, stack or weight. It will be used frequently to retrieve instances of GameObject by their unique ID. Therefore, it will be implemented as a **HashMap or Map**, which has constant access and insert time.

The grid object in the class Grid will be implemented as a 2D array of GridCell, which has constant access and insert time, allowing for quick rendering of objects. Implementing a grid as a 2D array also help in development since it is easier to work with intuitively and have some programming caveats.

The Stack will be modeled as a Buffer, since it provides much of the functionality and will be mutated frequently. *Notes: While Scala's collection package does have an implementation of an actual stack, Buffer is used instead due to its familiarity and reliability.*

The **board** of a Scale will be modeled as an Array because its length is constant i.e the scale can not shrink or grow in length. Constant access speed is also one reason to choose Array over Buffer for the **board**.

# 5 Schedule

The program can be divided into different areas/sections, grouped by its role/concept that needed to be built, tested and documented. Here we also introduce the concept of **"core"** classes and objects, parts of the program that many other objects depend on them. In this project, they are the main Game class, Weigh-Scale-Stack classes and the Player class. These represents the fundamental ideas of the game and with them, gameplay is achieved. Other classes will be build on top of them to either adding additional functionality like save/load file or display them to the user either in a graphical UI or on the console.

Different areas/sections will require different amount of time to go through the 3 phase mentioned above (built, test, document), with the core classes and the UI being the most demanding ones.

- The first two weeks (**22.2** - 7.3) will be dedicated to build and test different functionalities of these core classes. The bot algorithm may or may not be implemented in this period since it is not immediately essential and can be separated.
- The week after (8.3 - 14.3) will be dedicated to implement and test the save/load file functionality of the game. This will be important for testing the UI and the bot algorithm since generating test case will be much easier. Noted that the first interim report is due on 17.3.
- The next 2.5 weeks (15.3 - 31.3) will be dedicated to build and test the UI for the game, on the console and graphically in a window. Noted: the second interim report is due on 31.3.
- The next two weeks (1.4 - 14.4) will be dedicated to system testing of the whole program, debugging, tuning, optimizing for performance and adding additional features where needed. The final interim report is also due at the end of this period, on 14.4.
- The final two weeks (14.4 - **28.4**) will be dedicated to writing the required documentation and act as a "buffer zone" if more time is needed to complete certain features.

# 6 Testing

## 6.1 System testing

For most functionalities and features, the program will be tested manually by typing onto the console (for text-only version) or interacting with the graphical UI directly (in a graphical window). The UI and the display of game state will be manually tested for the most part with some aspect of the testing will be automated if needed. Saving/loading game state and testing will be frequently used in tandem. The saved game file will be designed and modified accordingly depending on which aspect of the game is being tested.

The goal for system testing is to minimize the chance of having bugs and glitches in the final product and of course, verify that the game did what it supposes to do and all its functionalities work correctly. System testing will also assess other aspect of the program, for example, its user experience: is it intuitive enough that anyone can pick up and use ? Is the game good at communicating its information to the user? etc . . . .

The test might be checking:

- The weight is placed at the correct location according to the user inputs.
- All the information of the game such as the score, the round number, the number of weights, etc . . . is displayed correctly.
- The canvas displays the current state of the game and update when a new weight is placed.
- . . .

## 6.2 Unit testing

Individual component and function in the program will also be tested the during implementation of the project. This is done to catch bugs and exceptions immediately when coding and not later when testing other part of the program. However, not all components and methods will need test case designed for them. Simple "get", "set" and "short 1 liners" method will not be unit-tested.

Some important "core" methods which are used frequently through out the program might have "edge cases" and exceptions that only show up when implementing other components, when they are linked together. This is tested during integration testing.

Example of these "core" methods is *add_weight()* and *add_scale()* in class Game, which will have multiple test case designed for them, testing for different exceptions arose from invalid user inputs. Some of the test for these might include testing for appropriate handling of exceptions, for example, when an invalid position is chosen by the users. For *add_weight()*, it is when the location has already been occupied by a scale or is outside the scale altogether. Or for *add_scale()* , it is when there is a stack or scale already occupied the space.

Beside "core" methods, algorithms will also be tested frequently for accuracy and return values. The two algorithms that will be tested extensively is the bot's search algorithm for maximum score gain and the rendering algorithm for GridObject and Grid. The test cases will be written in the saved file format to represents different scenarios that the algorithm must either search for best move or render onto the screen.

# References

[1] R. Nystrom. *Game Programming Patterns*. Genever Benning, 2014.

[2] Scala collection. https://docs.scala-lang.org/overviews/collections-2.13/introduction.html.