

# Many-to-One Matching in a Team Based Game with Subjective and Objective Preferences

Implementation of a Program that uses a Many-to-One Matching Algorithm

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## Purpose

The goal of this project is to design and implement a program that uses a many-to-one matching algorithm in a real life situation. A theoretical team vs. team online game is used as the platform for the problem, with each team having a fixed roster of a certain size to fill with players. The solution to the matching problem would place players who participate in the matching system on teams according to the matching algorithm used.

## Background

Matching markets contain two distinct groups of known agents, and aim to match each agent in one group to an agent in the other group. In a many-to-one matching, multiple agents of a particular group can be matched with one agent in the other group.

An assumption made in a matching problem is that agents in one group will have strict preferences for the agents in the other group. These preferences could be influenced by any number of different subjective or objective factors. In this project, the first group of agents will have a list of subjective preferences for agents in the second group, while the second group has a list of objective preferences for agents in the first group. Both lists of preferences will be used in the matching algorithm.

One of the main considerations for any matching algorithm is whether or not it results in a stable matching. A stable matching occurs when no pair of agents strictly prefer each other to the matches that they in, and would form a blocking pair. A matching algorithm has to ensure that there will be no blocking pairs, and in addition to that it must also ensure that agents would prefer to be matched over being unmatched, so that they would actually participate.

In order to model a matching mechanism for simple team vs. team game that could be played by different players online, there will be two sides to the matching market – players and teams. These two sides will each be modeled in the program in the context of the game in order to determine how two-sided matching would pick teams.

## Problem Statement

Defense of the World of MoonCraft is an online game in which teams of four players go head to head with other teams in order to fight for world domination. A league

featuring a number of elite teams will be held to determine who reigns supreme. There is a pool of qualified players, and every player will be placed on exactly one team to the teams that will compete in the league. All team rosters must be of a certain size that is specified by the game. Each player that participates in the matching can be matched with one team only.

There are four skill categories in the game that determine the total skill level of a team: attack, defense, intelligence, and resource production.

Each team will have a strategy, which is determined by weighting each of the four skill categories with a value between 0 and 100 (inclusive), with the total sum value of the four weights for categories no greater than 100. This strategy influences which players the teams would prefer, as the players have different skill sets that match up with the team strategy differently.

Each player will have individual ratings between 0 and 100 (inclusive) for each of the four skill categories, which represent to the player's skill level in those respective categories.

In addition, each player will have an ordered list of preferences, ranking the teams that they wish to be on from highest to lowest.

A team's total skill level is determined by the sum of each player's skill level on that team.

## **Approach**

A team's strategy (weights for each of the 4 skill categories) and each player's skill set (individual ratings for the 4 skill categories) are given, as well as each player's preference list for teams they wish to be on.

In order to formulate an algorithm that takes the preferences of both teams and players into account, it is necessary to have an ordered preference list for both those groups that participate in the matching market. Since players already have a preference list that ranks teams, it is necessary to generate a preference list for teams that ranks players. That way, it is possible to proceed with the matching algorithm. To generate this list of preferences for teams, the team's strategy and each player's skill set can be used in order to rank the players.

Taking a vector that represents a team's strategy and a vector that represents a player's skill set, we can calculate how well the player fits the team strategy by taking the scalar product of the team strategy and player skill set. A higher result would indicate a better team-to-player fit than a lower result.

Player fit = (weight for attack, weight for defense, weight for intelligence, weight for resource production)  $\square$  (player attack skill, player defense skill, player intelligence skill, player resource production skill)

Using this result, it is then possible to rank each player and create a preference lists for teams of players that fit a team's strategy the most. This list of player fits, along with a given player's list of preferred teams, can be used in a matching algorithm.

The algorithm would be written in a manner so that there would be no way for a player to switch to a team that they preferred more and be a better match for that team than another player already on that team.

Game specifications:

- 4 categories: attack, defense, intelligence, resource production

Team specifications:

- Exactly 3 players per team
- Strategy, with weights for 4 game categories (total weight 100)

Player specifications:

- Skill level for 4 game categories (each rating between 1-100)
- Team preference list

Matching specifications:

- 10 teams
- 30 players
- 3 players per team, 1 player matched with exactly 1 team

## **Considerations**

Depending on the distribution of team strategies and the player skill sets, there will be different demands for each of the game categories (attack, defense, intelligence and resource production). This means that certain players will be valued higher than others, which would be reflected by team preferences, and how much a player's preference is taken into account in the final matching.

Additionally, each game category could affect the game in a different manner, which would also influence team preferences and where players are selected. For this simulation, each category contributes to the total team strength equally.

## **Input Files for Code:**

An input file titled “playerteaminfo.txt” with random player and team information was produced as input for the program.

File contents:

1. Teams with 4 weights for 4 skill categories representing team strategy.

One line for every team, that follows the below format:

Team TeamName A:25 D:25 I:25 R:25

2. Players with 4 skill levels for the 4 skill categories and a strictly ordered list of preferences for teams.

One line for every player, that follows the below format:

Player PlayerName A:25 D:25 I:25 R:25

Preferences:TeamName,TeamName,TeamName,TeamName

### **Output of Code:**

Lines of input file read, along with the number of teams and players retrieved from the file.

List of each player with a team preference list.

List of each team with player preference list calculated using team strategy and each player’s skill set to find each player’s fit.

Output from every round of the matching algorithm, including current rosters and the players who propose, and are added to or removed from potential matches according to the matching algorithm.

Final matching of all teams with rosters, as well as team stats calculated from each player on the team roster.

### **Results**

The results of a matching simulation using the file playerteaminfo.txt are shown below.

41 lines read in file "playerteaminfo.txt"  
30 players created.  
10 teams created.

Player: Poliwhag | Preferences: Water Ground Grass Psychic Fighting Flying Ice Steel Electric Fire  
Player: Cyndaquil | Preferences: Fire Flying Electric Grass Steel Psychic Fighting Ground Water Ice  
Player: Chikorita | Preferences: Grass Ground Water Fire Psychic Fighting Steel Electric Flying Ice  
Player: Flareon | Preferences: Fire Ground Fighting Grass Flying Psychic Electric Water Ice Steel  
Player: Growlithe | Preferences: Fire Ground Fighting Steel Electric Flying Grass Ice Water Psychic  
Player: Jolteon | Preferences: Electric Fighting Grass Flying Psychic Steel Ground Fire Ice Water  
Player: Squirtle | Preferences: Water Fighting Grass Ice Steel Ground Psychic Flying Fire Electric  
Player: Tangela | Preferences: Grass Ground Fighting Psychic Water Electric Steel Ice Flying Fire  
Player: Totodile | Preferences: Water Ice Flying Steel Psychic Electric Fighting Grass Ground Fire  
Player: Magnemite | Preferences: Electric Steel Flying Psychic Fire Ice Grass Water Fighting Ground  
Player: Magmar | Preferences: Fire Ground Steel Fighting Psychic Grass Electric Flying Water Ice  
Player: Voltorb | Preferences: Electric Steel Ground Flying Grass Fire Water Ice Fighting Psychic  
Player: Seel | Preferences: Water Ice Ground Steel Electric Grass Fighting Psychic Fire Flying  
Player: Pikachu | Preferences: Electric Grass Fighting Fire Flying Ground Psychic Steel Ice Water  
Player: Shellder | Preferences: Water Ice Ground Steel Fighting Grass Psychic Fire Electric Flying  
Player: Ponyta | Preferences: Fire Grass Psychic Ground Fighting Flying Water Ice Steel Electric  
Player: Vaporeon | Preferences: Water Ice Psychic Ground Fighting Grass Flying Steel Electric Fire  
Player: Scyther | Preferences: Grass Fighting Steel Flying Electric Ground Ice Psychic Water Fire  
Player: Marill | Preferences: Water Ground Grass Psychic Fighting Steel Ice Flying Electric Fire  
Player: Pinsir | Preferences: Grass Ground Fighting Steel Electric Fire Ice Water Fire  
Player: Wobuffet | Preferences: Water Ground Steel Fighting Ice Psychic Electric Fire Grass Flying  
Player: Staryu | Preferences: Water Psychic Ice Fighting Flying Ground Grass Steel Fire Electric  
Player: Oddish | Preferences: Grass Water Electric Ground Flying Fighting Ice Psychic Steel Fire  
Player: Lapras | Preferences: Water Psychic Electric Ice Grass Ground Flying Steel Fire Fighting  
Player: Omanyte | Preferences: Water Ground Steel Fighting Ice Fire Grass Electric Psychic Flying  
Player: Charmander | Preferences: Fire Electric Ground Steel Flying Ice Psychic Fighting Grass Water  
Player: Mareep | Preferences: Electric Grass Psychic Fire Steel Fighting Water Flying Ice Ground  
Player: Goldeen | Preferences: Water Grass Fighting Steel Ice Psychic Electric Fire Ground Flying  
Player: Bulbasaur | Preferences: Grass Ground Psychic Fighting Water Steel Ice Flying Electric Fire  
Player: Electabuzz | Preferences: Electric Grass Steel Fire Psychic Fighting Ground Water Ice Flying

Team: Ice | Preferences: Goldeen Tangela Pikachu Voltorb Oddish Growlithe Staryu Magmar Chikorita  
Omanyte Poliwhag Jolteon Mareep Marill Electabuzz Wobuffet Charmander Seel Scyther Cyndaquil Pinsir  
Shellder Flareon Ponyta Magnemite Squirtle Bulbasaur Totodile Vaporeon Lapras  
Team: Fire | Preferences: Shellder Seel Oddish Tangela Staryu Goldeen Marill Voltorb Chikorita  
Squirtle Mareep Poliwhag Omanyte Magnemite Ponyta Growlithe Wobuffet Bulbasaur Flareon Magmar  
Charmander Totodile Pikachu Electabuzz Jolteon Cyndaquil Lapras Scyther Vaporeon Pinsir  
Team: Flying | Preferences: Growlithe Pikachu Electabuzz Goldeen Marill Scyther Omanyte Voltorb  
Wobuffet Seel Charmander Tangela Magmar Flareon Oddish Pinsir Ponyta Bulbasaur Staryu Squirtle  
Shellder Lapras Jolteon Totodile Cyndaquil Poliwhag Chikorita Magnemite Mareep Vaporeon  
Team: Ground | Preferences: Pikachu Growlithe Electabuzz Goldeen Marill Scyther Magmar Pinsir  
Charmander Wobuffet Omanyte Flareon Voltorb Tangela Jolteon Seel Oddish Cyndaquil Ponyta Lapras Staryu  
Bulbasaur Totodile Poliwhag Chikorita Squirtle Vaporeon Mareep Shellder Magnemite  
Team: Grass | Preferences: Growlithe Goldeen Wobuffet Omanyte Magnemite Electabuzz Pinsir Charmander  
Scyther Voltorb Pikachu Bulbasaur Shellder Flareon Seel Poliwhag Squirtle Tangela Cyndaquil Mareep  
Magmar Totodile Vaporeon Marill Chikorita Staryu Jolteon Oddish Lapras Ponyta  
Team: Steel | Preferences: Pikachu Growlithe Electabuzz Goldeen Marill Tangela Seel Voltorb Magmar  
Oddish Omanyte Scyther Flareon Ponyta Charmander Wobuffet Lapras Staryu Pinsir Jolteon Squirtle  
Shellder Chikorita Totodile Bulbasaur Cyndaquil Poliwhag Mareep Vaporeon Magnemite  
Team: Psychic | Preferences: Goldeen Voltorb Tangela Shellder Omanyte Poliwhag Growlithe Magnemite  
Wobuffet Seel Mareep Staryu Oddish Charmander Chikorita Magmar Pikachu Scyther Pinsir Cyndaquil  
Bulbasaur Flareon Squirtle Marill Jolteon Electabuzz Totodile Vaporeon Ponyta Lapras  
Team: Electric | Preferences: Shellder Seel Magnemite Squirtle Bulbasaur Goldeen Growlithe Omanyte  
Voltorb Wobuffet Marill Tangela Poliwhag Flareon Charmander Totodile Mareep Staryu Oddish Electabuzz  
Chikorita Scyther Pikachu Vaporeon Cyndaquil Lapras Pinsir Magmar Ponyta Jolteon  
Team: Water | Preferences: Goldeen Growlithe Tangela Pikachu Voltorb Omanyte Electabuzz Seel Oddish  
Wobuffet Marill Staryu Magmar Shellder Charmander Poliwhag Scyther Chikorita Mareep Flareon Pinsir  
Magnemite Cyndaquil Jolteon Squirtle Bulbasaur Ponyta Totodile Vaporeon Lapras  
Team: Fighting | Preferences: Goldeen Growlithe Voltorb Tangela Seel Pikachu Shellder Omanyte  
Electabuzz Marill Wobuffet Oddish Staryu Charmander Poliwhag Magnemite Flareon Magmar Scyther Chikorita  
Squirtle Mareep Bulbasaur Pinsir Cyndaquil Jolteon Totodile Ponyta Vaporeon Lapras

Run matching algorithm.

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Round 1.

30 total players propose.

Player Poliwag proposes to: Water

- Player added: Poliwag

Player Cyndaquil proposes to: Fire

- Player added: Cyndaquil

Player Chikorita proposes to: Grass

- Player added: Chikorita

Player Flareon proposes to: Fire

- Player added: Flareon

Player Growlithe proposes to: Fire

- Player added: Growlithe

Player Jolteon proposes to: Electric

- Player added: Jolteon

Player Squirtle proposes to: Water

- Player added: Squirtle

Player Tangela proposes to: Grass

- Player added: Tangela

Player Totodile proposes to: Water

- Player added: Totodile

Player Magnemite proposes to: Electric

- Player added: Magnemite

Player Magmar proposes to: Fire

- Player added: Magmar

- Player rejected: Cyndaquil

- Cyndaquil is free to propose next round.

Player Voltorb proposes to: Electric

- Player added: Voltorb

Player Seel proposes to: Water

- Player added: Seel

- Player rejected: Totodile

- Totodile is free to propose next round.

Player Pikachu proposes to: Electric

- Player added: Pikachu

- Player rejected: Jolteon

- Jolteon is free to propose next round.

Player Shellder proposes to: Water

- Player added: Shellder

- Player rejected: Squirtle

- Squirtle is free to propose next round.

Player Ponyta proposes to: Fire

- Player added: Ponyta

- Player rejected: Magmar

- Magmar is free to propose next round.

Player Vaporeon proposes to: Water

- Player added: Vaporeon

- Player rejected: Vaporeon

- Vaporeon is free to propose next round.

Player Scyther proposes to: Grass

- Player added: Scyther

Player Marill proposes to: Water

- Player added: Marill

- Player rejected: Poliwag

- Poliwag is free to propose next round.

Player Pinsir proposes to: Grass

- Player added: Pinsir

- Player rejected: Chikorita

- Chikorita is free to propose next round.

Player Wobuffet proposes to: Water

- Player added: Wobuffet

- Player rejected: Shellder

- Shellder is free to propose next round.

Player Staryu proposes to: Water

- Player added: Staryu

- Player rejected: Staryu

- Staryu is free to propose next round.

Player Oddish proposes to: Grass

- Player added: Oddish
- Player rejected: Oddish
- Oddish is free to propose next round.

Player Lapras proposes to: Water

- Player added: Lapras
- Player rejected: Lapras
- Lapras is free to propose next round.

Player Omanyte proposes to: Water

- Player added: Omanyte
- Player rejected: Marill
- Marill is free to propose next round.

Player Charmander proposes to: Fire

- Player added: Charmander
- Player rejected: Charmander
- Charmander is free to propose next round.

Player Mareep proposes to: Electric

- Player added: Mareep
- Player rejected: Pikachu
- Pikachu is free to propose next round.

Player Goldeen proposes to: Water

- Player added: Goldeen
- Player rejected: Wobuffet
- Wobuffet is free to propose next round.

Player Bulbasaur proposes to: Grass

- Player added: Bulbasaur
- Player rejected: Tangela
- Tangela is free to propose next round.

Player Electabuzz proposes to: Electric

- Player added: Electabuzz
- Player rejected: Electabuzz
- Electabuzz is free to propose next round.

Current Team Rosters:

Team Ice:

Team Fire: Ponyta Growlithe Flareon

Team Flying:

Team Ground:

Team Grass: Pinsir Scyther Bulbasaur

Team Steel:

Team Psychic:

Team Electric: Magnemite Voltorb Mareep

Team Water: Goldeen Omanyte Seel

Team Fighting:

Free Players that Propose Next Round: 18

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Round 2.

18 total players propose.

Player Poliwhag proposes to: Ground

- Player added: Poliwhag

Player Cyndaquil proposes to: Flying

- Player added: Cyndaquil

Player Chikorita proposes to: Ground

- Player added: Chikorita

Player Jolteon proposes to: Fighting

- Player added: Jolteon

Player Squirtle proposes to: Fighting

- Player added: Squirtle

Player Tangela proposes to: Ground

- Player added: Tangela

Player Totodile proposes to: Ice

- Player added: Totodile

Player Magmar proposes to: Ground

- Player added: Magmar

- Player rejected: Chikorita

- Chikorita is free to propose next round.

Player Pikachu proposes to: Grass

- Player added: Pikachu

- Player rejected: Bulbasaur

- Bulbasaur is free to propose next round.

Player Shellder proposes to: Ice

- Player added: Shellder

Player Vaporeon proposes to: Ice

- Player added: Vaporeon

Player Marill proposes to: Ground

- Player added: Marill
- Player rejected: Poliwag
- Poliwag is free to propose next round.

Player Wobuffet proposes to: Ground

- Player added: Wobuffet
- Player rejected: Tangela
- Tangela is free to propose next round.

Player Staryu proposes to: Psychic

- Player added: Staryu

Player Oddish proposes to: Water

- Player added: Oddish
- Player rejected: Oddish
- Oddish is free to propose next round.

Player Lapras proposes to: Psychic

- Player added: Lapras

Player Charmander proposes to: Electric

- Player added: Charmander
- Player rejected: Mareep
- Mareep is free to propose next round.

Player Mareep proposes to: Grass

- Player added: Mareep
- Player rejected: Mareep
- Mareep is free to propose next round.

Player Bulbasaur proposes to: Ground

- Player added: Bulbasaur
- Player rejected: Bulbasaur
- Bulbasaur is free to propose next round.

Player Electabuzz proposes to: Grass

- Player added: Electabuzz
- Player rejected: Pikachu
- Pikachu is free to propose next round.

#### Current Team Rosters:

Team Ice: Shellder Totodile Vaporeon  
 Team Fire: Ponyta Growlithe Flareon  
 Team Flying: Cyndaquil  
 Team Ground: Marill Magmar Wobuffet  
 Team Grass: Electabuzz Pinsir Scyther  
 Team Steel:  
 Team Psychic: Staryu Lapras  
 Team Electric: Magnemite Voltorb Charmander  
 Team Water: Goldeen Omanyte Seel  
 Team Fighting: Squirtle Jolteon  
 Free Players that Propose Next Round: 7

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 Round 3.

7 total players propose.

Player Poliwag proposes to: Grass

- Player added: Poliwag
- Player rejected: Poliwag
- Poliwag is free to propose next round.

Player Chikorita proposes to: Water

- Player added: Chikorita
- Player rejected: Chikorita
- Chikorita is free to propose next round.

Player Tangela proposes to: Fighting

- Player added: Tangela

Player Pikachu proposes to: Fighting

- Player added: Pikachu
- Player rejected: Jolteon
- Jolteon is free to propose next round.

Player Oddish proposes to: Electric



- Player added: Oddish
  - Player rejected: Oddish
  - Oddish is free to propose next round.
- Player Mareep proposes to: Psychic
- Player added: Mareep
- Player Bulbasaur proposes to: Psychic
- Player added: Bulbasaur
  - Player rejected: Lapras
  - Lapras is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Totodile Vaporeon  
 Team Fire: Ponyta Growlithe Flareon  
 Team Flying: Cyndaquil  
 Team Ground: Marill Magmar Wobuffet  
 Team Grass: Electabuzz Pinsir Scyther  
 Team Steel:  
 Team Psychic: Mareep Staryu Bulbasaur  
 Team Electric: Magnemite Voltorb Charmander  
 Team Water: Goldeen Omanyte Seel  
 Team Fighting: Tangela Pikachu Squirtle  
 Free Players that Propose Next Round: 5

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 Round 4.

- 5 total players propose.
- Player Poliwag proposes to: Psychic
- Player added: Poliwag
  - Player rejected: Bulbasaur
  - Bulbasaur is free to propose next round.
- Player Chikorita proposes to: Fire
- Player added: Chikorita
  - Player rejected: Flareon
  - Flareon is free to propose next round.
- Player Flareon proposes to: Ground
- Player added: Flareon
  - Player rejected: Flareon
  - Flareon is free to propose next round.
- Player Jolteon proposes to: Grass
- Player added: Jolteon
  - Player rejected: Jolteon
  - Jolteon is free to propose next round.
- Player Oddish proposes to: Ground
- Player added: Oddish
  - Player rejected: Oddish
  - Oddish is free to propose next round.
- Player Lapras proposes to: Electric
- Player added: Lapras
  - Player rejected: Lapras
  - Lapras is free to propose next round.
- Player Bulbasaur proposes to: Fighting
- Player added: Bulbasaur
  - Player rejected: Bulbasaur
  - Bulbasaur is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Totodile Vaporeon  
 Team Fire: Chikorita Ponyta Growlithe  
 Team Flying: Cyndaquil  
 Team Ground: Marill Magmar Wobuffet  
 Team Grass: Electabuzz Pinsir Scyther  
 Team Steel:  
 Team Psychic: Poliwag Mareep Staryu  
 Team Electric: Magnemite Voltorb Charmander  
 Team Water: Goldeen Omanyte Seel  
 Team Fighting: Tangela Pikachu Squirtle  
 Free Players that Propose Next Round: 5

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Round 5.

5 total players propose.

Player Flareon proposes to: Fighting  
- Player added: Flareon  
- Player rejected: Squirtle  
- Squirtle is free to propose next round.

Player Jolteon proposes to: Flying  
- Player added: Jolteon

Player Squirtle proposes to: Grass  
- Player added: Squirtle  
- Player rejected: Squirtle  
- Squirtle is free to propose next round.

Player Oddish proposes to: Flying  
- Player added: Oddish

Player Lapras proposes to: Ice  
- Player added: Lapras  
- Player rejected: Lapras  
- Lapras is free to propose next round.

Player Bulbasaur proposes to: Water  
- Player added: Bulbasaur  
- Player rejected: Bulbasaur  
- Bulbasaur is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Totodile Vaporeon  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Cyndaquil Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel:  
Team Psychic: Poliwhg Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 3

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Round 6.

3 total players propose.

Player Squirtle proposes to: Ice  
- Player added: Squirtle  
- Player rejected: Vaporeon  
- Vaporeon is free to propose next round.

Player Vaporeon proposes to: Psychic  
- Player added: Vaporeon  
- Player rejected: Vaporeon  
- Vaporeon is free to propose next round.

Player Lapras proposes to: Grass  
- Player added: Lapras  
- Player rejected: Lapras  
- Lapras is free to propose next round.

Player Bulbasaur proposes to: Steel  
- Player added: Bulbasaur

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Cyndaquil Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur  
Team Psychic: Poliwhg Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 2

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Round 7.

2 total players propose.

Player Vaporeon proposes to: Ground

- Player added: Vaporeon
- Player rejected: Vaporeon
- Vaporeon is free to propose next round.

Player Lapras proposes to: Ground

- Player added: Lapras
- Player rejected: Lapras
- Lapras is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Cyndaquil Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur  
Team Psychic: Poliwhag Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 2

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Round 8.

2 total players propose.

Player Vaporeon proposes to: Fighting

- Player added: Vaporeon
- Player rejected: Vaporeon
- Vaporeon is free to propose next round.

Player Lapras proposes to: Flying

- Player added: Lapras
- Player rejected: Cyndaquil
- Cyndaquil is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Lapras Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur  
Team Psychic: Poliwhag Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 2

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Round 9.

2 total players propose.

Player Cyndaquil proposes to: Electric

- Player added: Cyndaquil
- Player rejected: Cyndaquil
- Cyndaquil is free to propose next round.

Player Vaporeon proposes to: Grass

- Player added: Vaporeon
- Player rejected: Vaporeon
- Vaporeon is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Lapras Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur  
Team Psychic: Poliwhag Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander

Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 2

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Round 10.

2 total players propose.

Player Cyndaquil proposes to: Grass

- Player added: Cyndaquil
- Player rejected: Cyndaquil
- Cyndaquil is free to propose next round.

Player Vaporeon proposes to: Flying

- Player added: Vaporeon
- Player rejected: Vaporeon
- Vaporeon is free to propose next round.

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Lapras Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur  
Team Psychic: Poliwhag Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 2

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Round 11.

2 total players propose.

Player Cyndaquil proposes to: Steel

- Player added: Cyndaquil

Player Vaporeon proposes to: Steel

- Player added: Vaporeon

Current Team Rosters:

Team Ice: Shellder Squirtle Totodile  
Team Fire: Chikorita Ponyta Growlithe  
Team Flying: Oddish Lapras Jolteon  
Team Ground: Marill Magmar Wobuffet  
Team Grass: Electabuzz Pinsir Scyther  
Team Steel: Bulbasaur Cyndaquil Vaporeon  
Team Psychic: Poliwhag Mareep Staryu  
Team Electric: Magnemite Voltorb Charmander  
Team Water: Goldeen Omanyte Seel  
Team Fighting: Tangela Pikachu Flareon  
Free Players that Propose Next Round: 0

End algorithm, final matchings found.

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Final Team Rosters

Team Ice  
Team Players: Shellder Squirtle Totodile  
Team Attack: 45  
Team Defense: 110  
Team Intelligence: 66  
Team Resource Production: 53  
Total Team Skill: 274

Team Fire  
Team Players: Chikorita Ponyta Growlithe  
Team Attack: 70  
Team Defense: 52  
Team Intelligence: 80  
Team Resource Production: 66  
Total Team Skill: 268

Team Flying  
Team Players: Oddish Lapras Jolteon  
Team Attack: 65  
Team Defense: 53  
Team Intelligence: 99  
Team Resource Production: 81  
Total Team Skill: 298

Team Ground  
Team Players: Marill Magmar Wobuffet  
Team Attack: 74  
Team Defense: 56  
Team Intelligence: 69  
Team Resource Production: 60  
Total Team Skill: 259

Team Grass  
Team Players: Electabuzz Pinsir Scyther  
Team Attack: 112  
Team Defense: 58  
Team Intelligence: 66  
Team Resource Production: 34  
Total Team Skill: 270

Team Steel  
Team Players: Bulbasaur Cyndaquil Vaporeon  
Team Attack: 82  
Team Defense: 96  
Team Intelligence: 65  
Team Resource Production: 52  
Total Team Skill: 295

Team Psychic  
Team Players: Poliwag Mareep Staryu  
Team Attack: 57  
Team Defense: 75  
Team Intelligence: 51  
Team Resource Production: 86  
Total Team Skill: 269

Team Electric  
Team Players: Magnemite Voltorb Charmander  
Team Attack: 70  
Team Defense: 92  
Team Intelligence: 43  
Team Resource Production: 52  
Total Team Skill: 257

Team Water  
Team Players: Goldeen Omanyte Seel  
Team Attack: 57  
Team Defense: 72  
Team Intelligence: 46  
Team Resource Production: 55  
Total Team Skill: 230

Team Fighting  
Team Players: Tangela Pikachu Flareon  
Team Attack: 79  
Team Defense: 49  
Team Intelligence: 67  
Team Resource Production: 57  
Total Team Skill: 252

## Analysis

The matching mechanism implemented follows a player-proposing deferred acceptance model, and going through the results showed that there were no blocking pairs in the final matching.

This model was chosen as the algorithm of choice for this particular problem because it incentivizes truthful reporting from the players, as truthful reporting of their preferences would maximize their expected welfare from the matching and gives the players no reason to deviate from a truthful report.

There were no players that could switch to a new team that was higher on their preference list and be a better fit for that team than another player on the new team. Therefore the matching algorithm is stable as would be expected from this type of system.

The players were chosen as the proposing group rather than the teams due to the structure of the game – it was more beneficial to ensure truthful reporting from the players because their preferences were subjective and would be much easier to misreport if there was an incentive to do so in order to be matched with different teams.

The way the game would be structured, teams would be more robust against misreports because the preference lists of players that the teams have are obtained using an objective method using team and player stats that the game would prevent misreports of. The game structure would ensure that teams would not be able to benefit from misreporting their strategies by fixing the strategies that teams would choose to employ even before the matching algorithm started and the players were visible to the teams. The strategy for each team and the strategy reported would have to be the same per the way the game and matching mechanism works. Likewise, players would not be able to misreport their skill levels for the game since they would be stored in a verifiable database.

In multiple examples run by changing the file with different data, including the number of teams, players, team size, and stats, all matchings of teams to players were found to be stable, which indicated the success of the algorithm to meet its goal.

Another observation from running the matching mechanism with different sets of data was that although the teams were often evenly matched in terms of total skill level, there were also instances in which certain teams would be imbalanced with a high standard deviation off the mean. This was simply due to the randomness in the player skill sets and fit of the teams, as sometimes there were teams that simply did not have many players that fit well on their team while other teams had multiple highly skilled players with good fits.

Considering all the varying strategies of teams and the number of different players with different skill sets, achieving a good balance of skill level amongst all the teams could be an area to improve the mechanism. This would give the algorithm another level of importance in trying establish a league of teams with good parity and balance (especially with random gameplay) between the skill levels of the teams, which would lead to a competitive, exciting, and entertaining experience for the players.

## **Conclusion**

As a student who is slowly learning the basics of computer programming, and someone who is simply curious about economic theory and how it applies to everyday life, this project was a good chance for me to further explore a topic of interest by creating a problem modeled after a real world application.

In order to solve a many-to-one matching problem based on a theoretical team based game, it was necessary to think about how to represent the preferences for both teams and players in the matching market, so that these preferences could be used in the algorithm to place players onto teams. The algorithm, a player proposing deferred acceptance mechanism, was used to generate a stable matching for the players and teams. This algorithm was chosen for this problem due to the stability of the results, how well it fit the game structure, and the fact that it has the potential to produce balanced results for the teams given a pool of random players and teams.

Overall, I was happy that I was able to think through the problem of designing and implementing this mechanism, and although it took many iterations and a much longer time than I thought to get it working, the code has the capacity to extend to any size game, with different parameters and rules with a small amount of modification. Changing how much a team strategy affects the team preferences for each category, setting different levels of influence each of the skill categories has on the total skill of the team, or adding player handicaps or bonuses are just a few ways in which this program could eventually be extended to yield a team matching mechanism that could go along with a more advanced team vs. team game like the ones so many people play today.

## **Source Code**

Source code is found in the src folder.