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DFL-Opt : A Daily Fantasy Lineup Optimizer

Francis Aurori

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DFL-OPT: A DAILY FANTASY LINEUP OPTIMIZER

A Paper

Submitted to

the Faculty of the Department of Computer Science

Montclair State University

By

Francis Aurori

In Partial Fulfillment

of the Requirements for the Degree of

MASTER OF SCIENCE

May 2020

Montclair, New Jersey



MS Project Approval

May 8th, 2020

Date of Approval

I hereby recommend that the Master's project prepared under my supervision by

Francis Aurori

entitled

DFL-OPT: A DAILY FANTASY LINEUP OPTIMIZER

Be accepted in partial fulfillment of the requirements for the degree of

Master of Science in Computer Science

Recommendation concurred in

1. Dr. Vaibhav K. Anu (Advisor)

_____  _____

2. Dr. Aparna S. Varde

_____  _____

3. Dr. Dawei Li

_____  _____

Abstract

[Background] Daily fantasy sports (DFS) are a variety of fantasy sports where contests take place in a matter of days or hours rather than over a whole season. A disparity exists between skilled professionals and casual participants in the creation of line-ups (i.e. teams) w.r.t their chances of winning in these contests. The purpose of the current project was to create a user-friendly, open source platform (named DFL-Opt) for participants of all skill levels to utilize in the creation of DFS line-ups. In addition, efficacy of the DFL-Opt platform was determined by playing the lineups generated by the DFL-Opt tool in real contests on the website, DraftKings.

[Method] The platform was developed using an optimization approach based on linear programming. Comparison of results was performed based on five contests involving DraftKings Showdown Captain Mode between February 24th, 2020 through March 2nd, 2020.

[Result] DFL-Opt generated lineups place in the top 95 percentile in three out of the five contests that were played. The remaining results were compromised by factors such as player injuries (such factors are currently not included in the scope of the DFL-Opt platform and are part of future work).

[Conclusion] Based on the results, this approach used by DFL-Opt tool is an effective strategy to create competitive line-ups in DFS contests regardless of level of professionalism/skills of contestants.

Keywords: lineup optimization; sports analytics, linear programming, daily fantasy sports.

1. Introduction

Fantasy sports style wagering was introduced to the public several decades ago and has grown significantly in popularity since that time. The Fantasy Sports Trade Association (FSTA) estimates that in the year 2017, 59.3 million people played fantasy sports in the U.S. and Canada and spent an average of \$556 a year to participate [1]. Fantasy sports originally began during the 1980s [2]. Participants (i.e., people who are taking part in the contest) created season long fantasy teams consisting of actual professional players (i.e., the athletes taking part in the sports games) obtained in either online or offline drafts. After the games were completed players' real-game statistics were gathered and compared to see whose (i.e., which participant's) fantasy team outperformed the others. Participants tracked how their teams performed using numerous websites, such as Yahoo.com/Fantasy [3] and Espn.com/Fantasy[4]. Users could join leagues with friends or join public leagues with strangers and compete against one another. In addition to this traditional fantasy style where the teams were season long, participants could also create and play in other fantasy contests lasting for a day or a weekend. These contests were called "Daily Fantasy Sports".

Daily fantasy sports (DFS) contests typically last one day and are extremely fast paced. They include wagering of significant amounts of money with significant risk of loss and limited chance of winning and therefore some consider it to be a form of illegal gambling [5]. On the other hand, 43 US states, including New Jersey and New York, determined that DFS is legal as it requires knowledge and skill to create winning combinations/teams [6]. Although DFS has been determined to be a game of skill, a major skills gap exists between highly skilled participants compared to less knowledgeable casual participants. In the first half of the 2015 Major League Baseball season, 91 percent of DFS winnings or payouts were won by just 1.3% of the

participants, the majority of whom were considered professionals [7]. Due to this disparity, there is significant concern that the skilled participants (or DFS professionals) will eliminate the recreational or casual participants, which in turn will effectively decrease the overall prize pool of the contest and remove the general competitiveness of the contests.

Participants in these DFS contests spend a great deal of time and effort reviewing data in order to increase their chances of creating a winning combination and placing at the top of fantasy contests. Presently, there are websites such as RotoGrinders [8] that provide advanced analytics available to all participants that can potentially reduce the effect of the skills gap. Optimizer tools, which are an additional aid available to lessen the skill gap between DFS professionals and casual contestants to create DFS teams, can help in identifying what combination of players would produce the highest fantasy point value given certain constraints. The current project provides one such aid, DFL-Opt (*D*aily *F*antasy *L*ineup *O*ptimizer). DFL-Opt is a line-up optimization tool, which was developed and evaluated to help less-skilled or casual DFS participants in selecting combinations of players to optimize chances of winning.

There are existing tools that support fantasy sports line-up optimization. Hunter, Vielma, and Zaman created optimization software using Integer Programming to select the best lineups in fantasy hockey guaranteed prize pool tournaments (GPP) [9]. Analysis of results demonstrated a consistent winning pattern. Additionally, Giovanni Pantuso used a stochastic programming approach for an optimization model with the objective of maximizing the expected value of a team in European Football[10]. Even though these optimization models were found to be useful, they were restricted to Hockey and European Football sports.

The DFL-Opt project is focused on daily fantasy games associated with National Basketball Association (NBA). More specifically, the focus is on a type of DFS game style

known as Showdown Captain Mode (see section 2.a for more details on this mode). There is no existing tool that supports optimization for Showdown Captain Mode.

DFL-Opt provides a simple, easy-to-use interface, which does not require participants to be particularly tech-savvy in order to use the application. Additionally, optimizers provided by FantasyPros and RotoGrinders require a usage fee. I intend to provide DFL-Opt as a free service. It will also be an open source platform encouraging other developers to expand the application to other game styles and to make improvements to the graphical user interface based on their own necessities.

DFL-Opt uses a linear programming-based approach to support the participants in the creation of their own teams. The tool is capable of generating up to 200 optimized line-ups (i.e., teams) for the participants. The main goal of this approach is to maximize the potential for achieving greater total fantasy points given certain data requirements (see section 2.c for more on the data requirements). I compared the results from actual DFS gameplay to the teams created by my approach to determine the efficacy of my approach and to verify that it is a viable strategy to assist in creation of league teams by participants (i.e., contestants) of all skill-levels, whether professional or casual.

The rest of this document is organized as follows: Section 2 provides a brief background on fantasy sports, Section 3 provides the implementation details of the DFL-Opt tool, Section 4 provides an illustrated user guide, Section 5 describes the evaluation of DFL-Opt tool, and Sections 6 and 7 describe future work and concluding remarks, respectively.

2. Background

Currently, daily fantasy sports platforms are operated by two major companies, FanDuel [11] and DraftKings [12]. In 2009, FanDuel became the first major daily fantasy sports firm. Several years later DraftKings began accepting participants. Both companies offer the following sports contests for its users to participate in: football (NFL), baseball (MLB), hockey (NHL), soccer, basketball (NBA), golf (PGA), and certain college sports. DraftKings offers a greater variety of sport contests than FanDuel that includes Mixed Martial Arts (UFC), eSports, and reality shows.

For the purposes of this project it was decided that a single platform, DraftKings would be utilized for evaluating the approach as the project objective involved an initial investigation to determine the feasibility and efficacy of the approach.

a. Daily Fantasy Game Styles

There are multiple game styles that participants can join. DraftKings offers three game styles to choose from. For evaluation purposes, the game style selected for this analysis was limited to DraftKings NBA Showdown Captain Mode. In this mode participants create lineups by selecting players from a Player Pool. A Player Pool is a list of players playing in an actual professional event scheduled on a given day. Every individual player has a unique price, “salary”, which is which is determined mostly by the player’s outcomes in previous games. Salaries of players can range from \$3,000 (rarely used players) to \$12,000 (superstars). Each lineup may not exceed a maximum salary cap of \$50,000. Participants are required to create a lineup including 1 Captain and 5 Utility players. The player drafted as the Captain will earn 1.5x the standard fantasy point value for each statistic. Drafting a player as the Captain, however, will cost 1.5x a utility player’s salary. For instance, if the Captain scores 10 standard fantasy point

values the participant will then earn 15 fantasy points. Furthermore, if a player’s normal salary is \$3,000 it will increase to \$4,500 if selected as Captain.

DraftKings NBA contest fantasy points (Pts) are accumulated by each player as follows: 1 Pt per actual game point scored, 0.5 Pts per rebound, 1.25 Pts per assist, 2 Pts per steal, 2 Pts per block, .5 Pts per 3-point shot scored, -0.5 Pts per turnover (deduction), 1.5 Pts per Double-Double, 3 Pts per Triple-Double. A double-double and triple-double is defined as the attainment of a double-digit total in two or three of the five statistical categories (points, rebounds, assists, steals, and blocked shots) over the course of a single game. For example, if a player accumulates 10 points, 10 rebounds, and 10 assists in a single game he will earn 1.5 Pts for a double-double and 3 Pts for a triple-double. The scoring system for the NBA Showdown Captain Mode is demonstrated in Table 1.

Scoring:	Fantasy Points *
Statistic	
Point	1
Rebound	1.25
Assist	1.5
Steal	2
Block	2
Turnover	-0.5
Double- Double	1.5
Triple-Double	3
Made 3pt Shot	0.5

Table 1: Scoring for DraftKings NBA Showdown Captain Mode

*** The Captain is 1.5x standard fantasy point value**

A participant's performance is based on upon the performance of a lineup selected for a given contest on a given day. A participant's total fantasy points are compared to the other contestants to determine the winner. For example, if a player has 5 points scored, 2 assists, 2 rebounds, and 1 block. This player will have a total of 12.50 fantasy points. The sum of points scored by players in a lineup is considered total fantasy points accumulated by a participant in the particular contest.

b. Daily Fantasy Sports Contests

There are a variety of contests in daily fantasy sports with associated diverse payout structures. One type of contest is known as double-ups or 50/50 contests. The main goal is for the participants to finish in the top half as only the top 50% of contestants are considered winners and receive payment. The lower 50% of participants are considered to have lost and thus their entry fees are not reimbursed. As an example, in a typical 50 person \$10 50/50 game, the 25 players with the highest score will all double-up their entry fee and get paid, whereas the bottom 25 players will lose their \$10 entry fee.

DraftKings also offers large field type contests called Guaranteed Prize Pool Tournaments, GPP for short. These are very top-heavy tournaments where only a predetermined percentage of participants win and receive payment. These contests have entry fees that can range from \$0 (complementary play) to \$5,300. The winners of GPP contests can potentially win up to \$1,000,000. Potential winnings are significantly higher than the entry fees required. The odds of winning, however, are decreased proportionately. These contests are offered to contestants with single entry or multiple entry. Multiple entries allow participants to spread their entries over a large variance of players to increase chances of winning top prize money. For

example, participants who enter a 10% GPP contest will only be paid if they score in the top 10% of points won in the contest. The remaining 90% will lose their entry fees.

c. Daily Fantasy Sports Lineup

Participants in daily fantasy contests enter a lineup consisting of a set of players in a particular sport. There are constraints on the selection of players used to build a lineup. Each player has a salary (in dollars). Each player's salary varies day-to-day and is based upon past and predicted performances. Lineups must be created within a fixed budget. For example, in DraftKings basketball contests, there is a \$50,000 budget cap for each lineup. Additional constraints include the maximum number of players allowed per lineup as well as the number of different teams players may be selected from to create a lineup. In DraftKings basketball contests, participants are required to select players from at least two different teams. The results from each contest are determined by the total points accumulated by each separate lineup entry. The potential performance of each player selected for a lineup is an unknown variable. The decision to choose between hundreds of players is difficult, but there are helpful resources that provide highly accurate predictions of players potential performance and ability to score points such as RotoGrinders [8] and FantasyLabs [13].

3. Implementation

This section describes the system architecture and the lineup generation algorithm used by the DFL-Opt tool

a. System Architecture

The overall system architecture for the application is shown in Figure 1.

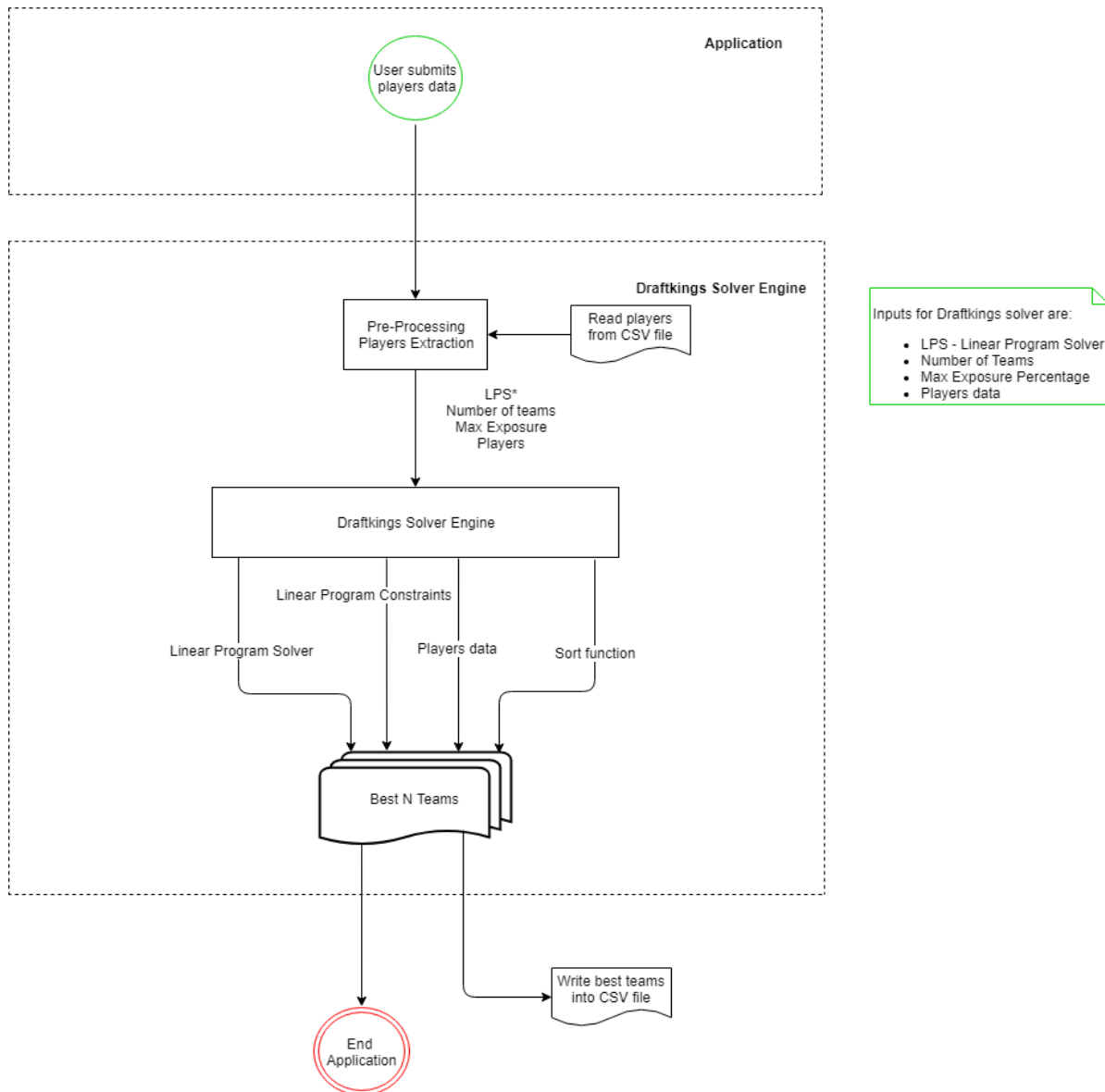


Figure 1: System Architecture Diagram

DFL-Opt's architecture is made up of the following three major aspects:

1. Application Interface: User submits the player data.
2. Pre-Processing Players: Read players from CSV file. Next, the DraftKings Solver is called and takes inputs of Linear Program Solver, number of teams, max exposure percentage, and player data.
3. DraftKings Solver Engine: After the DraftKings Solver is called, the solver takes inputs of the linear program, the linear program constraints, players data, and uses a sort function to produce the best "n" lineups. The lineups will be written into a CSV file and the execution will be concluded.

b. UML Class Diagram

The classes used for the backend development were Player, DraftkingsSolver, CsvHelper, Constants, and Main. The Player class has attributes of position, name, salary, gameinfo, team, rosterPosition, and value. The Player class has a constructor player() and print() method. The print() method prints the player information. Dependency relationship is a relationship in which one element, the client, uses or depends on another element, the supplier. In our class diagram, class Player has a dependency relationship with class Constants as it takes the values of the attributes of class Constants. The main method executes the program.

CsvHelper is another class. This class has a constructor CsvHelper(), read(String, int):List<Player> and write_results_to__csv(List<Player>, int[] [], String, int) methods. The read method reads the csv file and write_results_to__csv writes the final teams into a csv file.

CsvHelper has a dependency with the Player class as it is calling the methods from Player. It also

has a dependency relationship with the Constants class as it takes the values of the attributes of class Constants.

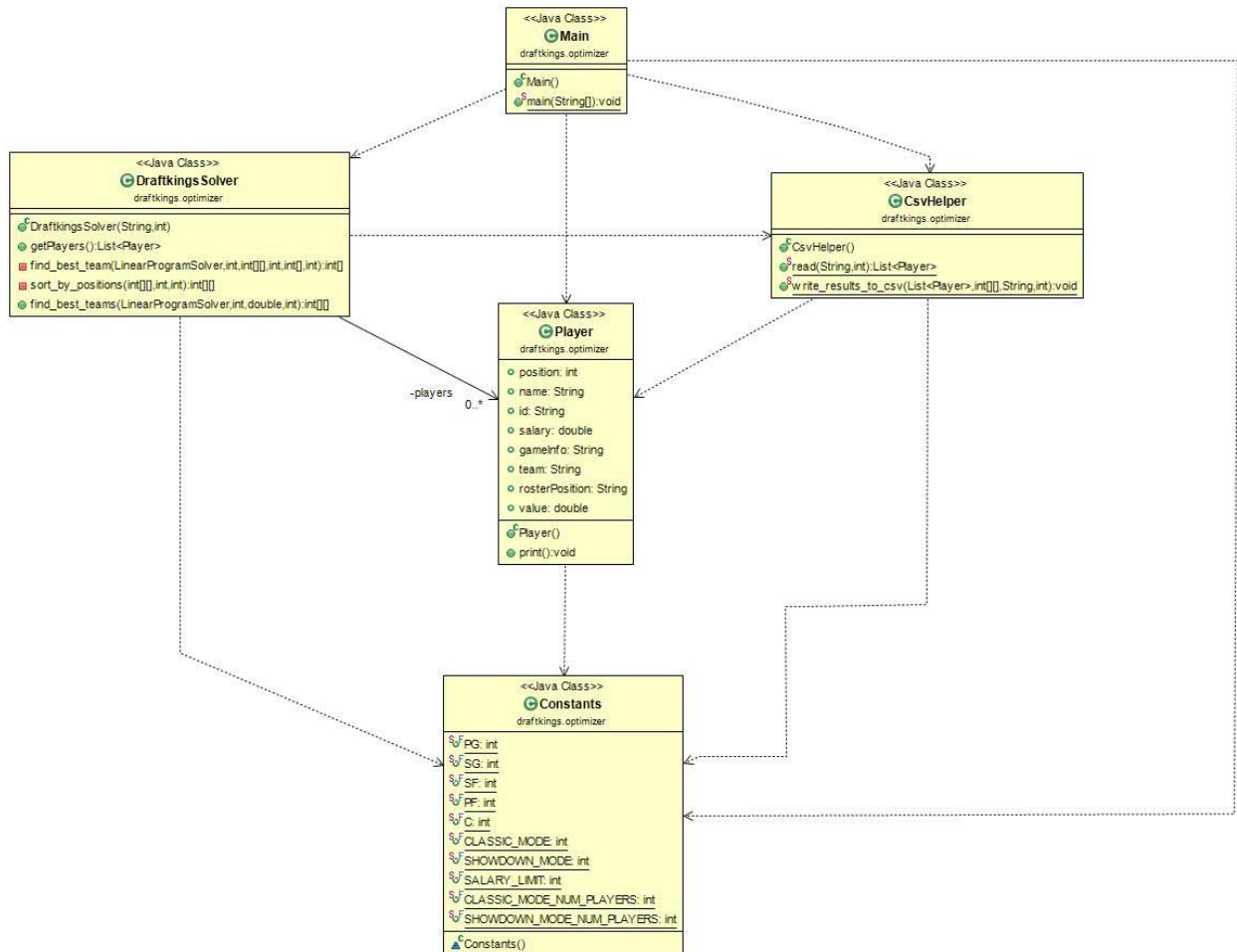


Figure 2: UML Class Diagram

DraftkingsSolver is the last class created. This class has a constructor DraftkingsSolver(String, int), and getPlayers(), find_best_team(LinearProgramSolver , int, int[][], int, int, int) (private), sort_by_positions(int[][], int, int) and find_best_teams(LinearProgramSolver, int, double, int) (public) methods. The getPlayers() method gets the list of players. Find_best_team is a private method which will find the single

best team and will return a list of the selected players. The `sort_by_positions` method will sort each team by the player positions, in our case captain and utility players. This public method `find_best_teams` will find the “n” best teams, where “n” is determined by the user. Association is drawn as a solid line connecting two classes. In our class diagram, class `DraftkingsSolver` and `Player` class are associated, because `DraftkingsSolver` has attribute of type `Player`.

Cardinality indicates the number of occurrences that one entity has relative to another. In our case, the cardinality `0..*` means that `DraftkingsSolver` could have many attributes of type `Player` in it. E.g. `DraftkingsSolver` association to `Player1`, `DraftkingsSolver` association to `Player2`, etc. `DraftkingsSolver` has a dependency relationship with the `CsvHelper` class as it is calling the methods from `CsvHelper`. It also has a dependency relationship with the `Constants` class as it takes the values of the attributes of class `Constants`.

Class `Constants` provides variables that are static and final. These variables are constant throughout the program. The only variables that were used for our application for Showdown contests were `SHOWDOWN_MODE: int`, `SALARY_LIMIT: int`, and `SHOWDOWN_MODE_NUM_PLAYERS: int`. The other variables in our `Constants` class are used for another `DraftKings` contest mode type, the `Classic Mode`, which is still being designed.

c. DFL-Opt’s Lineup Generation Algorithm

Assuming we have m players to choose from when making a team. A player can be selected in a team as captain (CPT) or as Utility (UTIL). A player’s salary and value depend on position (CPT or UTIL) he is selected for. To simplify the model we will duplicate each player, one for CPT position and another for UTIL. Formally, we have a set $P = \{1, 2, \dots, m, m + 1, m + 2, \dots, 2m\}$ of $2 \times m$ players to choose from where i and $i + m$ represent the same player but two different positions. Let $P_{\text{CPT}} = \{1, 2, \dots, m\}$ and $P_{\text{UTIL}} = \{m + 1, m + 2, \dots, 2m\}$ denote the

set of players that can be chosen as CPT and UTIL respectively. The salary of a player i ($1 \leq i \leq 2m$) - depending on position of course - will be denoted by $salary(i)$ and its value by $val(i)$ (value is 1.5 times greater if player is selected as captain). Let T denote the set of teams.

Decision variables

For each player $i \in P$ we have a decision variable x_i telling us if player is selected or not i.e.

$$x_i = \begin{cases} 1, & \text{if player } i \text{ is selected to the best team} \\ 0, & \text{otherwise} \end{cases}$$

Figure 3: Decision Variable

Constraints

$$\sum_{i \in P} x_i \times salary(i) \leq 50000 \quad (1)$$

$$\sum_{i \in P} x_i = 6 \quad (2)$$

$$\sum_{i \in P_{CPT}} x_i = 1 \quad (3)$$

$$\forall i \in [1, 2, \dots, m] \quad x_i + x_{i+m} \leq 1 \quad (4)$$

$$\forall t \in T \quad \sum_{i \in t} x_i \leq 5 \quad (5)$$

Figure 4: Constraint Variables

Constraint (1) ensures that a player's total salary does not exceed 50,000. Constraints (2) and (3) ensures that a team must have six players selected in a team and exactly one of them is the captain. A player cannot be selected as CPT and UTIL concurrently and this is enforced by constraint (4). The last constraint (5) is used to make sure that players from at least two teams are selected (this is equivalent to saying that no more than 5 players belong to the same team).

Objective function

Function to maximize is

$$\sum_{i \in P} x_i \times val(i)$$

Figure 5: Objective Function

4. User Guide

This section describes a step-by-step user guide to help new users understand the lineup generation process.

Figure 6 shows the landing page that the user sees when the application is opened. The user first needs to import the player data.

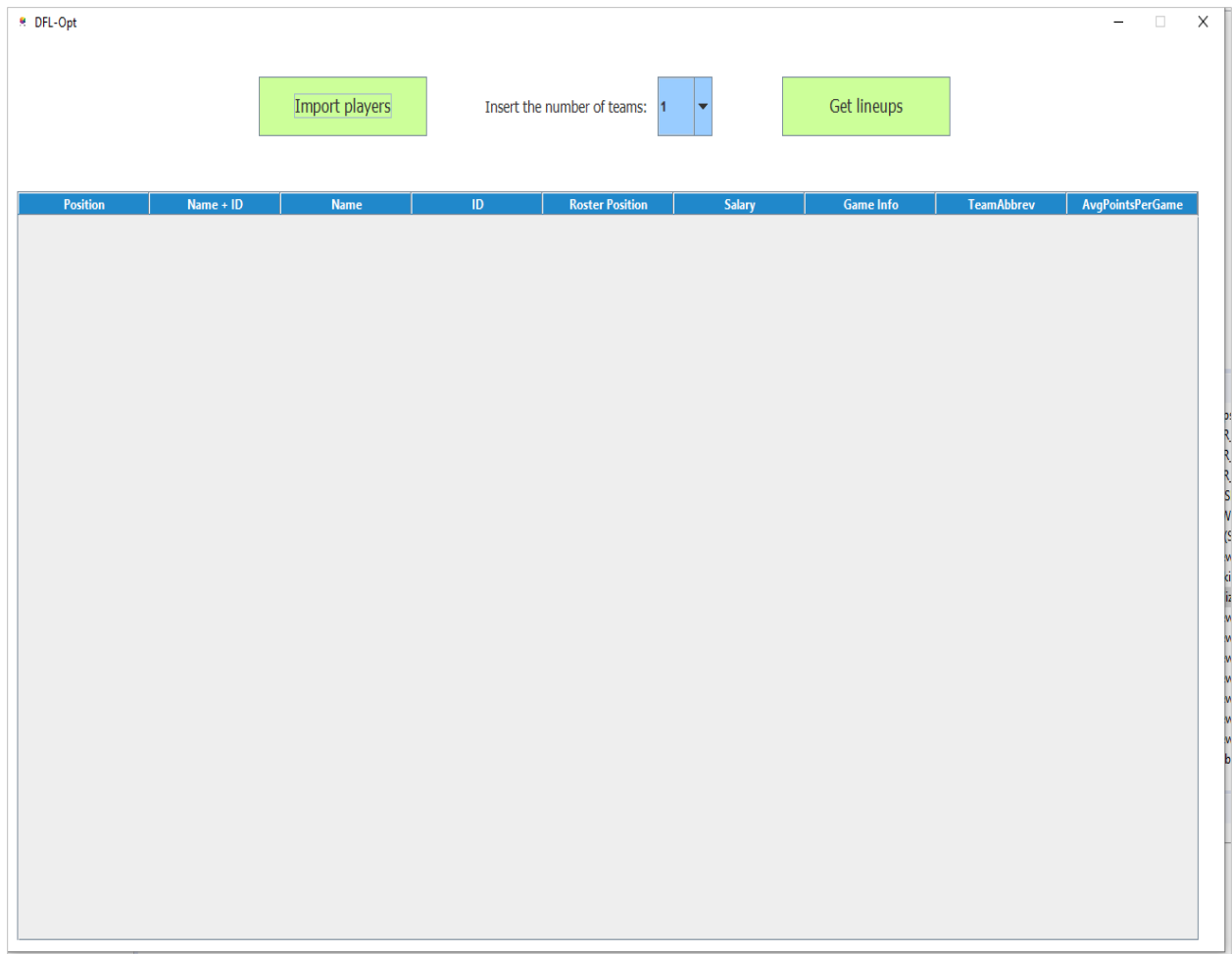


Figure 6: Main User Interface

When the user clicks on “import players” button, they will need to find the correct path for the file that’s saved on their computer (Figure 7). The data is the same format as the CSV file from Draftkings.com that the participants can export from the DraftKings contests.

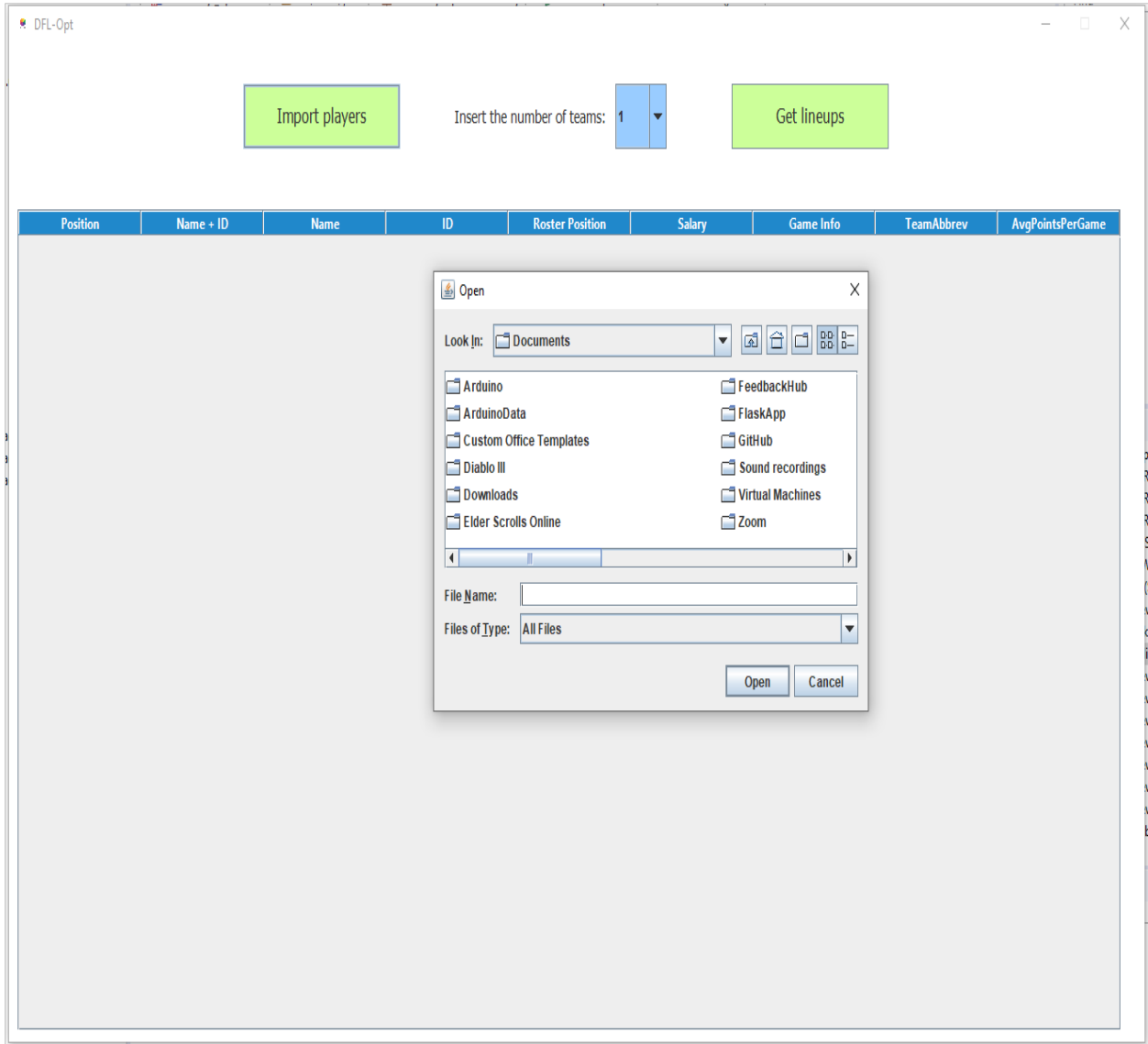


Figure 7: Importing CSV file

DFL-Opt

Import players

Insert the number of teams: 1

Get lineups

ALL CPT UTIL

Position	Name + ID	Name	ID	Roster Position	Salary	Game Info	TeamAbbrev	AvgPointsPerGame
SG	Andre Iguodala 14386171	Andre Iguodala	14386171	CPT	1800.0	MIL@MIA 03/02/2020 0...MIA		14.8
SG	Andre Iguodala 14386137	Andre Iguodala	14386137	UTIL	1200.0	MIL@MIA 03/02/2020 0...MIA		9.9
C	Bam Adebayo 14386148	Bam Adebayo	14386148	CPT	14700.0	MIL@MIA 03/02/2020 0...MIA		62.0
C	Bam Adebayo 14386114	Bam Adebayo	14386114	UTIL	9800.0	MIL@MIA 03/02/2020 0...MIA		41.3
C	Brook Lopez 14386155	Brook Lopez	14386155	CPT	8400.0	MIL@MIA 03/02/2020 0...MIL		34.2
C	Brook Lopez 14386121	Brook Lopez	14386121	UTIL	5600.0	MIL@MIA 03/02/2020 0...MIL		22.8
SG	Cameron Reynolds 14386180	Cameron Reynolds	14386180	CPT	1500.0	MIL@MIA 03/02/2020 0...MIL		0.0
SG	Cameron Reynolds 14386146	Cameron Reynolds	14386146	UTIL	1000.0	MIL@MIA 03/02/2020 0...MIL		0.0
C	Chris Silva 14386170	Chris Silva	14386170	CPT	1800.0	MIL@MIA 03/02/2020 0...MIA		0.0
C	Chris Silva 14386136	Chris Silva	14386136	UTIL	1200.0	MIL@MIA 03/02/2020 0...MIA		0.0
PF	D.J. Wilson 14386168	D.J. Wilson	14386168	CPT	2400.0	MIL@MIA 03/02/2020 0...MIL		0.0
PF	D.J. Wilson 14386134	D.J. Wilson	14386134	UTIL	1600.0	MIL@MIA 03/02/2020 0...MIL		0.0
SF	Derrick Jones Jr. 14386160	Derrick Jones Jr.	14386160	CPT	6300.0	MIL@MIA 03/02/2020 0...MIA		23.1
SF	Derrick Jones Jr. 14386126	Derrick Jones Jr.	14386126	UTIL	4200.0	MIL@MIA 03/02/2020 0...MIA		15.4
PG	Donte DiVincenzo 14386156	Donte DiVincenzo	14386156	CPT	7800.0	MIL@MIA 03/02/2020 0...MIL		23.3
PG	Donte DiVincenzo 14386122	Donte DiVincenzo	14386122	UTIL	5200.0	MIL@MIA 03/02/2020 0...MIL		15.5
SG	Duncan Robinson 14386157	Duncan Robinson	14386157	CPT	7500.0	MIL@MIA 03/02/2020 0...MIA		32.6
SG	Duncan Robinson 14386123	Duncan Robinson	14386123	UTIL	5000.0	MIL@MIA 03/02/2020 0...MIA		21.7
PG	Eric Bledsoe 14386151	Eric Bledsoe	14386151	CPT	12300.0	MIL@MIA 03/02/2020 0...MIL		43.7
PG	Eric Bledsoe 14386117	Eric Bledsoe	14386117	UTIL	8200.0	MIL@MIA 03/02/2020 0...MIL		29.1
PF	Ersan Ilyasova 14386161	Ersan Ilyasova	14386161	CPT	5700.0	MIL@MIA 03/02/2020 0...MIL		0.0
PF	Ersan Ilyasova 14386127	Ersan Ilyasova	14386127	UTIL	3800.0	MIL@MIA 03/02/2020 0...MIL		0.0
PG	Frank Mason III 14386177	Frank Mason III	14386177	CPT	1500.0	MIL@MIA 03/02/2020 0...MIL		0.0
PG	Frank Mason III 14386143	Frank Mason III	14386143	UTIL	1000.0	MIL@MIA 03/02/2020 0...MIL		0.0
PG	Gabe Vincent 14386178	Gabe Vincent	14386178	CPT	1500.0	MIL@MIA 03/02/2020 0...MIA		0.0
PG	Gabe Vincent 14386144	Gabe Vincent	14386144	UTIL	1000.0	MIL@MIA 03/02/2020 0...MIA		0.0

Figure 8: Player Data

Once the file is uploaded the participants can update any of the information in the file and can filter by either Captain or Utility players (as shown in Figure 8).

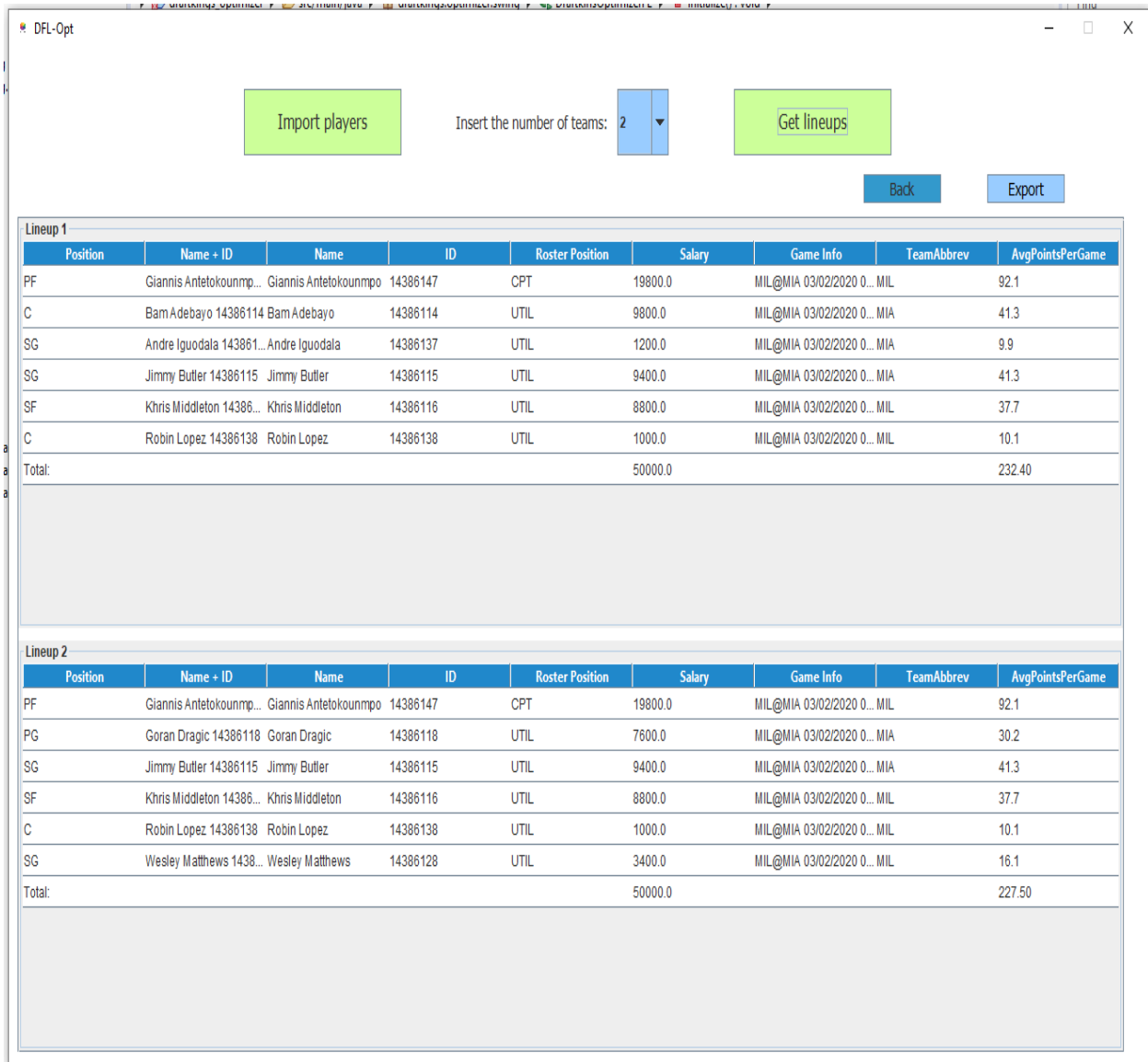


Figure 9: “N” Best Teams

The next step is for the user to select how many teams/lineups they want, which is shown in Figure 9.

DFL-Opt

Import players Insert the number of teams: 2 Get lineups

Back Export

Lineup 1								
Position	Name + ID	Name	ID	Roster Position	Salary	Game Info	TeamAbbrev	AvgPointsPerGame
PF	Giannis Antetokounmpo...	Giannis Antetokounmpo	14386147	CPT	19800.0	MIL@MIA 03/02/2020 0...	MIL	92.1
C	Bam Adebayo 14386114	Bam Adebayo	14386114	UTIL	9800.0	MIL@MIA 03/02/2020 0...	MIA	41.3
SG	Andre Iguodala 143861...	Andre Iguodala	14386137	UTIL	1200.0	MIL@MIA 03/02/2020 0...	MIA	9.9
SG	Jimmy Butler 14386115	Jimmy Butler	14386115	UTIL	9400.0	MIL@MIA 03/02/2020 0...	MIA	41.3
SF	Khris Middleton 14386...	Khris Middleton	14386116	UTIL	8800.0	MIL@MIA 03/02/2020 0...	MIL	37.7
C	Robin Lopez 14386138	Robin Lopez	14386138	UTIL		MIL@MIA 03/02/2020 0...	MIL	10.1
Total:								232.40

Message

Lineups exported successfully!

OK

Lineup 2								
Position	Name + ID	Name	ID	Roster Position	Salary	Game Info	TeamAbbrev	AvgPointsPerGame
PF	Giannis Antetokounmpo...	Giannis Antetokounmpo	14386147	CPT	19800.0	MIL@MIA 03/02/2020 0...	MIL	92.1
PG	Goran Dragic 14386118	Goran Dragic	14386118	UTIL	7600.0	MIL@MIA 03/02/2020 0...	MIA	30.2
SG	Jimmy Butler 14386115	Jimmy Butler	14386115	UTIL	9400.0	MIL@MIA 03/02/2020 0...	MIA	41.3
SF	Khris Middleton 14386...	Khris Middleton	14386116	UTIL	8800.0	MIL@MIA 03/02/2020 0...	MIL	37.7
C	Robin Lopez 14386138	Robin Lopez	14386138	UTIL	1000.0	MIL@MIA 03/02/2020 0...	MIL	10.1
SG	Wesley Matthews 1438...	Wesley Matthews	14386128	UTIL	3400.0	MIL@MIA 03/02/2020 0...	MIL	16.1
Total:								50000.0

Figure 10: Exported Data

The user will select “Get lineups” and DFL-Opt will show each lineup with the best lineup at top. The users can select “export”, which will export the lineups into a CSV in the format that DraftKings will accept in order to upload multiple lineups on their website (as shown in Figure 10).

5. Evaluation of the DFL-Opt Tool

This section describes the evaluation performed to assess the overall functionality and accuracy of the DFL-Opt application. Analysis was performed by applying the approach to NBA basketball contests in DraftKings. The sample size included five (5) datasets of actual live NBA Showdown Captain Mode contests based on NBA basketball games played between February 24th, 2020 and March 2nd, 2020. The sample size was limited due to the Covid-19 pandemic which resulted in the suspension of the 2019-2020 NBA season on March 11, 2020.

Results were analyzed by comparing projected point values of lineups generated by DFL-Opt tool with the actual points scored by the lineup generated as well as total points scored by the winner of each of the contests. Table 2 provides the results of this analysis.

Contest and Date	Number of line-ups (proposed by DFL-Opt) that were played during the contest	Rank of the DFL-Opt's best-placed line-up	Projected fantasy-points score of best placed line-up	Actual points scored by the best placed line-up	Points scored by the contest winner's line-up
Timberwolves vs Mavericks (Date: 2/24/20)	10	274 out of 8225 lineups (97th percentile)	295.7 fantasy points	228.38 fantasy points	231.88 fantasy points
76ers vs Cavaliers (Date: 2/26/20)	10	3079 out of 7134 lineups (57th percentile)	226.3 fantasy points	159.75 fantasy points	228.63 fantasy points
Knicks vs 76ers (Date: 2/27/20)	10	138 out of 7134 lineups (98th percentile)	241.48 fantasy points	276.38 fantasy points	290.38 fantasy points
Bulls vs Knicks (Date: 2/29/20)	10	430 out of 9512 lineups (95th percentile)	242.55 fantasy points	236 fantasy points	250.38 fantasy points
Bucks vs Heat (Date: 3/2/20)	10	989 out of 7134 lineups (86th percentile)	273.25 fantasy points	196.38 fantasy points	222.25 fantasy points

Table 2: Comparison of My Best Lineup vs Winning Lineup

The first dataset that was collected has been described in the first row of Table 2. This dataset was based on an NBA Showdown \$2K Quarter Jukebox contest utilizing players from a game between the Minnesota Timberwolves and the Dallas Mavericks. My approach gave my best placing lineup a projected value of 295.7 fantasy points. The actual lineup scored 228.38 fantasy points, a difference of 67.33 fantasy points. The discrepancy initially appeared significant. The top placing lineup (the winner), however, only scored 231.88 fantasy points, a difference of 3.5 fantasy points between the actual points scored. The best-placed lineup generated by my approach placed 274th out of 8225 lineups (97th percentile).

The second dataset that was collected has been described in the second row of Table 2. This dataset was based on an NBA Showdown \$1.5K Quarter Jukebox contest utilizing players from a game between the Philadelphia 76ers and the Cleveland Cavaliers. My approach gave my best placing lineup a projected value of 226.3 fantasy points. The actual lineup scored 159.75 fantasy points, a difference of 66.55 fantasy points. The discrepancy occurred as a result of injury to the player selected as captain during the first quarter of the live game. The winning lineup in the contest accumulated 228.63 fantasy points. My lineup placed 3079 out of 7134 lineups (57th percentile).

The third dataset that was collected has been described in the third row of Table 2. This dataset was based on an NBA Showdown \$1.5K Quarter Jukebox contest, utilizing players from a game between the New York Knicks and the Philadelphia 76ers. My approach gave my best placing lineup a projected value of 241.48 fantasy points. The actual lineup scored 276.375 fantasy points, an increase of 34.9 fantasy points. The winning lineup scored 290.38, a difference of 14.01 fantasy points. The discrepancy occurred as a result of a player originally being ruled

out of play, but in turn played in the live game. The lineup, however, performed well and placed in the top 98th percentile, a place of 138th of 7134 total lineups.

The fourth dataset that was collected has been described in the fourth row of Table 2. This dataset was based on an NBA Showdown \$2K Quarter Jukebox contest, utilizing players from a game between the New York Knicks and the Chicago Bulls. My approach gave my best placing lineup a projected value of 242.55 fantasy points. The actual lineup scored 236 fantasy points, a difference of 6.55. The winning lineup of the contest scored 250.38 fantasy points, which was 14.38 points higher than my best lineup. Our lineup placed 430 out of 9512 total lineups, a percentile of 95th.

The fifth dataset that was collected has been described in the fifth row of Table 2. This dataset was based on an NBA Showdown \$1.5K Quarter Jukebox contest, utilizing players from a game between the Miami Heat and the Milwaukee Bucks. My approach gave my best placing lineup a total projected fantasy point value of 273.25. The actual lineup scored 196.37 fantasy points, a difference of 76.88 fantasy points. The discrepancy occurred as a result of a player being ruled a late scratch (ruled out of play). The winning lineup of the contest scored 222.25 fantasy points. This lineup placed 989 out of 7134 lineups (86th percentile).

Another analysis was performed to compare lineups generated by DFL-Opt tool vs contest-winning lineups. Table 3 through 7 show the results of this analysis. The list of players highlighted in green were players common to both lineups. The players listed in white were different players but were the same position.

Table 3 shows my best placing lineup compared to the winning lineup in Contest 1. Three of the utility players were the same and the captains were the same.

	Contest 1: NBA Showdown \$2K Quarter Jukebox (Timberwolves vs Mavericks)	
	My Lineup	Winning Lineup
UTIL	D'Angelo Russell	D'Angelo Russell
UTIL	Kristaps Porzingis	Tim Hardaway Jr.
UTIL	Malik Beasley	Malik Beasley
UTIL	James Johnson	James Johnson
UTIL	Kelan Martin	J.J. Barea
CPT	Luka Doncic	Luka Doncic

Table 3: Contest 1 - Lineup Comparison

	Contest 2: NBA Showdown \$1.5K Quarter Jukebox (76ers vs Cavaliers)	
	My Lineup	Winning Lineup
UTIL	Tobias Harris	Tobias Harris
UTIL	Kevin Love	Kevin Love
UTIL	Josh Richardson	Josh Richardson
UTIL	Shake Milton	Collin Sexton
UTIL	Furkan Korkmaz	Larry Nance Jr.
CPT	Joel Embiid	Tristan Thompson

Table 4: Contest 2 - Lineup Comparison

Table 4 shows my best placing lineup compared to the winning lineup in Contest 2. Three of the utility players were the same, but the captains were different.

Table 5 shows my best placing lineup compared to the winning lineup in Contest 3. Three of the utility players were the same and the captains were the same.

	Contest 3: NBA Showdown \$1.5K Quarter Jukebox (Knicks vs 76ers)	
	My Lineup	Winning Lineup
UTIL	Julius Randle	Julius Randle
UTIL	Elfrid Payton	Elfrid Payton
UTIL	Josh Richardson	Malik Beasley
UTIL	Al Horford	Al Horford
UTIL	Kyle O'Quinn	J.J. Barea
CPT	Tobias Harris	Tobias Harris

Table 5: Contest 3 - Lineup Comparison

	Contest 4: NBA Showdown \$2K Quarter Jukebox (Bulls vs Knicks)	
	My Lineup	Winning Lineup
UTIL	Zach LaVine	Julius Randle
UTIL	Thaddeus Young	Thaddeus Young
UTIL	Tomas Satoransky	Coby White
UTIL	Mitchell Robinson	Mitchell Robinson
UTIL	Moe Harkless	Taj Gibson
CPT	Julius Randle	Zach LaVine

Table 6: Contest 4 - Lineup Comparison

Table 6 shows my best placing lineup compared to the winning lineup in Contest 4. Two of the utility players were the same.

Table 7 shows my best placing lineup compared to the winning lineup in Contest 5. Two of the utility players were the same. Brook Lopez, who my approach selected as a utility player was selected as the captain in the winning line-up.

Contest 5: NBA Showdown \$1.5K Quarter Jukebox (Bucks vs Heat)		
	My Lineup	Winning Lineup
UTIL	Bam Adebayo	Bam Adebayo
UTIL	Jimmy Butler	Jimmy Butler
UTIL	<i>Brook Lopez</i>	Jae Crowder
UTIL	George Hill	James Johnson
UTIL	Robin Lopez	Pat Connaughton
CPT	Giannis Antetokounmpo	<i>Brook Lopez</i>

Table 7: Contest 5 - Lineup Comparison

The analyses shown in Table 2 through Table 7 shows that the DFL-Opt tool can successfully generate optimized lineups for contestants participating in daily fantasy sports. Although the sample size was small (data for five contests was collected), the approach appeared to be successful. The three best lineups (generated by DFL-Opt) placed in the top five (5) percent of all lineups in their respective contests. A larger sample size, in all probability would have substantiated favorable results.

6. Future Work

In the future, my goal is to improve the algorithm and add additional features to the Graphical User Interface (GUI) of the DFL-Opt tool. First, I will want the users of the application to have the opportunity of changing an individual player's maximal exposure. Exposure of a player is defined as the number of teams that a player may be selected to play for when multiple lineups are being created and it must not exceed a predetermined given value expressed as a percentage. For example, 50% maximal exposure means that player can be selected in no more than 50% of the teams being created. A potential solution to achieve optimization (i.e. solve the problem exactly) would involve using Integer Programming techniques.

Additionally, I plan on adding an up-to-date player news section to the application. This will allow participants to see recent news about crucial players while creating lineups. Access to player news is expected to have a huge impact on whether or not the contestant (i.e., participant) will win or lose during the contest.

I also intend on adding another contest to the application. This contest will cover the DraftKings Classic Mode. This contest is very different from the NBA Showdown Captain mode. The major difference is the way the lineups are constructed. The lineup requirements will consist of 8 players and the players must be from at least two different NBA games. The roster positions of these players that the participant must choose are as follows: 1 Point Guard (PG), 1 Shooting Guard (SG), 1 Small Forward (SF), 1 Power Forward (PF), and 1 Center, as well as 1 additional Forward (either SF or PF), 1 additional Guard (either PG or SG), and lastly 1 Utility player (any position).

Another future goal includes connecting a player database to the application. The player database would contain player data, such as up-to-date game statistics. It will also include player photos which will help add to the overall aesthetical features.

7. Conclusion

DraftKings and FanDuel are two of the major companies that control the daily fantasy sports (DFS) industry. Both companies offer multiple fantasy contests ranging from different sports to reality TV shows. Contestants can join different contest modes and game styles, ranging from multiple participant tournaments to head-to-head type matchups. In all forms of DFS contests, participants create teams/lineups utilizing real professional players with the goal of maximizing their lineups with the best fantasy point value. Each contest offered has different rules and requirements, but the goal remains the same: to produce the best lineup and place at the top of the contest. In 2017, almost 60 million people played daily fantasy sports. With popularity so high, large amounts of money are wagered.

Many believe activity related to daily fantasy sports (DFS) should be considered illegal gambling. DFS, however, is legal in 43 US states including New Jersey and New York, as the game requires knowledge and skill to create winning combinations/teams. It takes considerable knowledge and skill to consistently place at the top of these contests, and top prize money is won by only a small percentage of contestants, mostly DFS professionals.

The software developed in this project (i.e., DFL-Opt) helps alleviate a portion of the skill gap that exists between DFS professionals and casual participants. DFL-Opt is a simple user-friendly software that can help all participants to produce a multitude of lineups given players' data requirements.

An initial evaluation (provided in Section 5) showed that DFL-Opt produced near-winning lineups that ranked as high as 98th percentile in contests that featured 7000 to 8000 participants. Lineups generated by the DFL-Opt tool were played in five separate contests in

DraftKings' NBA Showdown Captain Mode between February 24th, 2020 and March 2nd, 2020.

The top-placed line-ups that were generated by DFL-Opt were consistently similar to the winning line-ups (see Tables 3 to 7 in Section 5). That is, the team compositions were more or less same as the contest-winning lineups. These results are encouraging and motivate further evolution of the DFL-Opt tool to further improve lineup optimization.

The DFL-Opt software currently caters to the DraftKings Showdown mode. Additional features will be added in the future to both frontend and backend to facilitate expansion of utilization.

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