Minjie Zheng   19 April 2011
6515 Wydown Blvd, No. 5746
Saint Louis, MO 63105

President Tryndamere
Riot Games Inc. President
6041 Bristol Pkwy
Culver City, CA 90230

Dear President Tryndamere,

As you are well aware, matchmaking is the most important element to a competitive gaming
environment. It determines the quality of game play that each player receives, reflects the skill levels of
the players, and establishes the basis of rank. Thus, an inadequate matchmaking algorithm will not only
inaccurately reflect a player's ranking in the competitive environment, but will also cause dissatisfactory
games for the players.

Currently, League of Legends, as it ascends to be the best competitive MOBA title, uses the ELO
matchmaking algorithm. Over time, many avid players have voiced their concerns regarding the
insufficiency of the ELO system. Furthermore, even the general pool of casual players expressed
discontentment in the quality of the games that they are receiving. I understand that the balancing team
at Riot Games has been working hard to improve the matchmaking system, but I believe the current
matchmaking algorithm should be completely redone. As an experienced computer scientist, a
mathematician and a loyal player, I will bring to your attention the major defects of the ELO algorithm
and propose a new matchmaking system that will better serve the competitive environment of League
of Legends.

Here are the major reasons why ELO is an inaccurate measurement of a player's skill:

- It was designed for Chess, which is a 1v1 game as opposed to the 5v5 team game in League of
  Legends.
- ELO rating of a player goes up or down solely based on if the team that the player was on won
  or lost. It does not account for individual performances since a player can be much more skillful
  than the opponents but was dragged down due to the incompetence of his teammates.
- The concept of an "ELO Hell" exists. This happens when a player with much higher skill level is
  "stuck" at a significantly lower rating due to him not being able to carry his other four
  teammates to victory every game.
- The contribution of a player's skill to the game's outcome cannot be determined with the ELO
  algorithm.

In general, the ELO algorithm fails mainly because it cannot account for the uncertainties in the team
environment of League of Legends.

The new matchmaking system that I am proposing has the following objectives:

- Account for individual performances in a game regardless of whether the team wins or loses.
- Factor champion selection as a measurement parameter. Different roles of champions are
  measured with different objectives. For example, tanks will be measured by how many lives
  they save while carries will be measured by how many kills they get.

- Incorporate dynamic rating change that accurately reflects the game outcome rather than a static increase or decrease for wins and losses.
- Implements a better queue that places players in games with others who are close in skill levels.

This new system focuses heavily on individual performances to measure a player's skill level. Since the ladder ranks by individual players and not teams, the new focus will reflect a more accurate representation of a player's relative skill to his peers. Another advantage of this proposal is that it will increase the quality of games, as a player would not be in a game where the skill levels are severely unbalanced.

The implementation and testing of the new matchmaking algorithm will ideally provide a better competitive gaming environment for the players of League of Legends. Since a robust matchmaking system forms the basis of a competitive game, I strongly urge you to consider the benefits of implementing the following proposal as League of Legends becomes the best title in the competitive MOBA scene.

Sincerely,

Minjie Zheng

Minjie Zheng

Revolution of the Massive-Online-Battle-Arena Rating System

A Proposal To Riot Games Inc.

Minjie Zheng
4/19/2011

Table of Contents

Executive Summary

Due to the competitive nature of human beings, rating systems are essential elements of everyday life. In most sports, they measure an individual's skill relative to another. Then, the ratings establish the rank. League of Legends, as the leading Massive-Online-Battle-Arena title, suffers greatly from an insufficient rating system that does not correctly reflect its players' skill levels. Because of this, its players are constantly complaining about experiencing unsatisfactory games.

The rating system that League of Legends currently uses is the Elo rating system. It was first developed by Arpad Elo in 1950, and it became the official rating system for United States Chess Federation in 1960 after Elo finalized the system with extensive statistical testing. It is a rating system for calculating the relative skill level between players since the absolute skill level of a player is impossible to calculate in theory. The system calculates an expected score of a player against another player based on their rating. If the player's actual score is higher than the expected score then the system adjusts the player's rating upwards, and if the player's actual score is lower than the expected score then the system adjusts the player's rating downwards. It is believed that if a player plays enough games, his rating will be an accurate representation of his true skill level.

Even though the Elo system is a very comprehensive rating system that correctly represents a player's true skill level in many areas, it is insufficient as the rating system for League of Legends. The main problem of the Elo system in League of Legends is the fact that League of Legends is a 5v5 team game, and it cannot account for all the uncertainties caused by your teammates' actions. It treats each team as a player and takes the average rating of all five players on the team as the rating for the team. Then, based on the outcome of the game, it adjusts all players' ratings on one team upward or downward. Because of this, many players end up at ratings that do not correctly represent their true skill level due to the performance of their teammates. As a result, games where players' skill levels are supposedly similar usually end up in a landslide for one team. Thus, the Elo system causes a lot of frustration for players who are not in their rating bracket due to unsatisfactory games.

The new rating system aims to solve all the defects of the Elo system in League of Legends. It focuses heavily on individual performances and gives different factors of importance based on the role of the champion a player is playing. The system identifies the major indicators for areas that measure a player's performance in League of Legends. The major indicators, as a consensus between the best players and the developers of the game, are kill and assist to death ratio, ward placement score, turret

score, creep kill score, and roaming score. The actual score of a player in the new system is calculated based on how well that player performed in those areas. Thus, the skill of a player is more correctly represented and their teammates' performances will have less impact on the change of that player's rating. Simulation of ten thousand players was done on both the Elo system and the new system. It is shown that the Elo system often has players whose true skills are in the top five percent of the player base end up in the lower end of the rating bracket due to being paired with unskilled teammates each game. However, the new system shows that even just after one hundred games played, most players' ratings somewhat correctly represented where their true skills are relative to the other players. This overwhelming difference between the new system and the Elo system clearly suggests that the new system should be implemented to further improve League of Legends as the best competitive MOBA title.

Introduction

Rating systems have been around ever since the beginning of history. The competitive nature of human beings exemplifies the need to establish one's worth compared to another. In the earlier days, gladiators were ranked based on their performances in the arena. With their rankings, relatively skilled fighters were pitched against each other to provide more exciting matches for both the viewers and the competitors. Throughout the ages, rating systems have evolved into more complicated forms backed by complicated mathematical algorithms. Competitive sports are good examples of such systems. Due to inherently different nature of each sport, every sport's association has its own way of calculating rating and ranking for its players and matching the players with relative skills to each other.

With the dawn of the internet age, a new form of competitive environment emerged: the Massive-Online-Battle-Arena (MOBA) genre as an e-sport. Ever since its debut, the rating system has always been the major complaint from the player base. Because of the team nature of the MOBA genre and the unpredictability of the performances of teammates, traditional individual rating systems have done a sub-par job reflecting the proper skill level of a player. League of Legends, as the leading title in the MOBA scene, suffers from this defect greatly.

This proposal examines the current rating system of League of Legends, the Elo system, and its pitfalls. Then, I will introduce a new comprehensive rating system designed just for League of Legends with its specifications and reasoning behind each rating factor. To draw my conclusion, I have thoroughly tested the new system in simulation and compared it to the Elo system in detail.

The Elo Rating System

History of Elo

Arpad Emrick Elo, a Hungarian-born American physics professor, developed the Elo rating system. It is an improved method for calculating relative skill levels of two players in games such as chess. The idea was first conceived by Kenneth Harkness, the Business Manager of the United States Chess Federation, in 1950. The algorithm was then improved over the next ten years by Arpad Elo through extensive data gathering with sound statistical basis. After its approval in 1960, the Elo rating system became the official rating system for the United States Chess Federation.

Basis of Elo Rating System

The central assumption of the Elo system is that the performance of each player in each game is a normally distributed random variable. Thus, even if the player may do better or worse from game to game, the mean value of the player's performance is the true skill level of the player. The Elo system also assumes a normal distribution with the mean and median at 1200 rating for all players. In other words, when every player starts at the mean rating, that player will eventually reach his true rating due to relative statistical significance.

The performance of a player in a game is calculated by:

$$Performance\ Rating = \frac{(Total\ of\ opponents'rating + 400*(Wins - Losses))}{Total\ Games\ of\ the\ Player}$$

Expected Score

Since Elo measures the relative skill level between players, it is an important tool to pair players against opponents with similar skill level so that no one has an overwhelming chance of winning. Matchmaking algorithms using the Elo system have thus been successful for two-player games as no one can choose their opponent to maximize their chance of winning. The Elo system accomplishes this by calculating the expected score of a player against another.

If Player A has true skill level of R_A and player B has true skill level of R_B, then the expected score for Player A, E_A, and expected score for Player B, E_B, can be calculated as follows:

$$E_A = \frac{1}{1 + 10^{(R_B - R_A)/400}}$$

and

$$E_B = \frac{1}{1 + 10^{(R_A - R_B)/400}}$$

The expected score basically makes a predication of how one player will fare against the other. For example, if Player A has an expected score of 0.75 against player B, it means that 75% of the time, Player should win the game against Player B.

How Ratings Are Calculated

Since we do not actually know a player's true skill level, it is almost impossible to determine R_A or R_B. However, the Elo system can make an accurate prediction of a player's true skill level by considering how the player has over-performed or under-performed relative to his current rating. Then, the Elo system will adjust the player's current rating based on his performance, and over time, the player's rating will reflect his true skill level.

The formula for updating a player's rating is:

$$R'_A = R_A + K(S_A - E_A)$$

R_A - the player's current rating

R'_A - the player's adjusted rating

K - k-factor (16 for higher rated players and 32 for lower rated players)

S_A - actual score of the player

E_A - expected score of the player

As the equation shows, if the actual score of the player is higher than expected then his rating will be adjusted upwards, and if the actual score of the player is lower than expected then his rating will be adjusted downwards. The reason for the k-factor is so that new players can move up faster if their actual skill level is very high, since all new players start at the mean of 1200 rating. After enough games, a player's rating will fluctuate over a very small range. Through statistically significant testing, that player's true skill level is within that range so the rating will accurately reflect his true skill level.

An example of Elo system in the works:

Player A has 1600 rating, and Player B has 1200 rating.

The expected score of Player B against Player A is: $\dfrac{1}{1+10^{(1600-1200)/400}} = \dfrac{1}{11}$

They play 10 games together and Player B ends up winning 8 of the games, so $S_B=8$.

Clearly if Player B is only expected to win 1 out of 11 games and he won 8 out of 10 games, he over-performed, so his rating should go up a lot.

By the algorithm, his new rating would be: $1200 + 32\left(8 - \dfrac{1}{11}\right) = 1453$

Current Pitfalls in League of Legends

Elo in League of Legends

League of Legends currently incorporates Elo as its rating system. Even though it is a team game, it is a battle between two teams of five in any match. Thus, the game treats each team as a player in individual matches by taking the average rating of all players on that team to be the team's rating. Then, based on the outcome of the game, each player on the team will gain or lose the same amount of rating based on the average rating of the teammates. In an ideal situation where everyone's rating on the team varies by

a very small amount, the Elo system can potentially represent the true skill level of individual players. However, due to the limited number of players online searching for a game at a given time, it is almost impossible to pair up ten players in an acceptably small range. Due to this factor, Elo does not accurately represent every player's skill level and often results in one-sided matches.

Why Elo does not work

- It is meant to calculate expected score of a single player against another player. When you have five people of different skill levels versus another five, the expected outcome becomes much more complicated since one player's performance can significantly influence the others on the same team.
- The team play environment of League of Legends can greatly influence the outcome of the game. Even for a team that consists of lower skilled people, if the team composition is more balanced and each member does his job, it can defeat a team consists of higher skilled people with less balanced champion selections.
- The negative effect of one bad player is much more detrimental to the team than the effect of a good player. For example, a team consists of 1600, 1400, 1400, 1400, and 1200 is paired against a team of all 1400s. Even though the averages of the team ratings are the same, the unbalanced team is more likely to lose due to the 1200 feeding the opposite team giving an advantage to the opponents.
- The snowball effect in League of Legends does not allow any small mistakes to be made early in game. A defeat in team fight in the beginning can determine the outcome of the game even if the players pull together and do decently later. The Elo system does not incorporate any mercy on such events.
- Only very good players can constantly carry the team to victory and end up at their appropriate skill level. Only very bad players can constantly destroy his team ending up at their respectively low rating. However, for the majority of the players in the middle, it is very frustrating being paired against people who did not belong at that skill level due to being "carried" by good players or "tanked" by bad players.

Elo Hell

The concept of Elo Hell is the most detrimental effect of using the Elo system for a team game like League of Legends. What most players refer to as the "Elo Hell" is the rating range in which you do not belong in but is hard to get out of. How does this happen? It is because everybody starts out at the median of 1200 rating. Unless you are exceptionally good, in which case your real skill level is above 2000 rating, most likely you will not be able to carry your teams to victory. At around the 1200 range, there are people who are either really good or really bad. Imagine a player whose real rating is about 1600. He starts his ranked game career at 1200 rating. With the millions of players in League of Legends, people with all kinds of skill levels can be at the 1200 rating because they just started ranked games. Thus, the 1600 player may get good players one game and get absolutely crushed in another, creating a vicious cycle in which that player is forever stuck at around 1200 rating, unable to get out.

In all, Elo cannot account for all the uncertainties and unpredictability in a dense team game such as League of Legends. There are too many factors that outright determine the outcome of the game and most of the time one bad person is enough to swing the odd in the other team's favor.

The New Rating System

Overview

With all the flaws of the Elo rating system in mind, I am here to bring you a new way of looking at rating systems in MOBA such as League of Legends. The objectives of the new system are the following:

- Account for individual performances in a game regardless of if the team wins or loses
- Factor champion selection as a measurement parameter. Different roles of champions are measured with different objectives. For example, tanks will be measured by how many lives they save while carries will be measured by how many kills they get
- Incorporate dynamic rating change that accurately reflects the game outcome rather than a static increase or decrease for wins and losses
- Implement a better queue that places players in games with others who are close in skill levels and can create more balanced teams

Since better players may not always win against worse players due to all the team factors, the goal of the new system is to find indicators that show the relative skills among players rather than their win/loss. For a dense game such as League of Legends, it will try to incorporate, if not all, most of the core elements of the game that determine the skill level of a player. It will then use all of the indicators to construct a performance score for each player in a particular game and determine if the player over- or under-performed with regard to his current rating. The formula to construct the performance score of a player is

$$S_A = \left(KDA \times \alpha + W_p \times \beta + T_s \times \gamma + C_s \times \delta + R_s \times \varepsilon\right) \times K_c + O$$

KDA - kill and assist to death ratio

W_p - ward placement score

T_s - turret score

C_s - creep kill score

R_s - roaming score

K_c - team composition factor

O - outcome bonus of the game (whether your team won or lost)

α, β, γ, δ, ε - factors based on different roles of the champion played (see p. 12-14 for more details)

Why These Indicators

Kill and assist to death ratio is unarguably the most important indicator of a player's skill level. If your ratio is positive, it means you are more capable than your opponents that you can keep them dead. Also, if you can kill your opponents, you are more likely to win the game since no one is there to stop your team from winning. Also, a largely positive KDA also means you are not reckless and die to opponents in the process of trying to get a kill. It encourages careful playing and really shows how a player performs in the game. However, in order to prevent defensive play style and kill-stealing from teammates, other indicators and the factors really play a role to determine how well a player does with respect to his champion's role.

Ward placement score is a deciding factor between a good player and a bad player. Since League of Legends is a team game at heart, good players will contribute to the team so they have the best chance at winning. When a player is simply chasing high KDA, he can put his own team at risk of losing because getting kills is not the objective but simply makes it harder for the other team to reach its objective. Map awareness is a highly advanced element of the game and good map awareness provides much less chance of anyone on your team dying. Ward placement is the direct measurement of how well you contribute to your team's map awareness, so it is an important indicator of how well you performed.

Turret score is another important indicator in how well a player does. The basic philosophy is that getting kills does not win you the game but pushing and destroying the enemy does. It is true that killing the enemy prevents the other team from winning, but if they can push the lanes better then they may win the game regardless. In addition, some champions' sole purpose is to push and destroy turrets. Thus, turret score play a large role in if a team does well or not.

Creep kill score is also another deciding factor between a good player and a bad player. A bad player can get kills if his team is doing well, but he would not know how to farm well. Being able to consistently last-hit creeps for gold is an important and advanced technique. Between highly skilled players, it is very hard to score kills off of the other team in the beginning, so all the gold comes from how skilled you are at farming during the laning phase. How many creeps you have killed can directly correlate to how well you contribute to team fights late in the game.

Roaming score is specifically for people who use champions whose purposes are to roam and gank. A successful roamer can turn the tide of the game from the very beginning. However, roamers usually have very low creep score as they do not lane during the laning phase. They simply help their teammates score kills and farm easier in the early stages. This indicator is for people who are successful roamers that contribute greatly to the team but would otherwise have a lower score in the other categories.

Team composition factor is a very important factor because, even if everyone on the team does well, if you did not pick someone that contributed to the team composition, your team may still lose. Thus, your performance is based on whether you successfully contributed to what your team needed during champion selection.

The outcome of the game is still an important factor even though the new rating system heavily focuses on individual performances. It indicates whether your team successfully accomplished the objective. This is now a small factor to the performance score rather than all of it.

Different Roles of Champions

As we all know, League of Legends has over 70 distinct champions that serve different purposes to a team. In order to create a good team, you not only need skilled players but a balanced champion selection that fills in every role a team needs. Due to the inherently different nature of each role of champions, we have to measure the performance of the player based on the type of champion he selected. The five main categories of champions are physical carries, magical carries, tanks, junglers, and supports, and they will each have a different criterion as to how the player should perform to fill that role. The exact factor associated with each indicator is calculated through numerous trials and testing to ensure the optimal value.

Physical Carries

Indicator factors:

α=0.7 β=0.05 γ=0.1 δ=0.15 ε=0 (see bottom of page for what they represent)

Purpose: These champions are sustained damage dealers late-game. They are the core source of damage of a team in determining the outcome of late-game team fights. Being the core source of damage late-game, farming and killing opponents are their most important job. A skilled physical carry should have very high KDA as he knows how to stay away from fights and deal the most sustained damage while not dying.

Effective Physical Carries: Ashe, Corki, Ezreal, Kog'Maw, Mater Yi, Miss Fortune, Nocturne, Sivir, Teemo, Tristana, Tryndamere, Twisted Fate, Twitch, Urgot

Magical Carries

Indicator factors:

α=0.6 β=0.05 γ=0.1 δ=0.15 ε=0.1 (see pg 11 for what they represent)

Purpose: These champions are burst damage dealers mid-game. They are the core damage of a team in the middle stage of the game. Their effective wanes off as game length increases. The main job of magical carries is to roam and gank during the middle stage of the game to keep the other team's physical carries from farming and getting kills. Thus, their significant portion of the factor is still KDA but now they include a decent factor for their roaming score.

Effective Magical Carries: Akali, Anivia, Annie, Brand, Cassiopeia, Fiddlesticks, Kassadin, Katarina, Kennen, Leblanc, Malzahar, Morgana, Nidalee, Poppy, Ryze, Sion, Swain, Veigar, Vladamir

α- kill and assist to death ratio factor β- ward placement score factor γ- turret score factor
δ-creep kill score factor ε-roaming score factor

Tanks

Indicator factors:

α=0.4 β=0.4 γ=0.1 δ=0.15 ε=0.05 (see pg 11 for what they represent)

Purpose: These champions do not do any damage but soak up damage for the teammates. They also often have crowd control skills to help carries score kills. They should not by any means have high kill counts, but they need to have a high assist to death ratio. Since they do not need expensive carry items, they are the ones that provide map awareness to the team through the form of purchasing wards. The most important job is for them to protect the carries from dying so they can deal the most damage to the opposing team. They are also the only ones who can successfully initiate a team fight without dying instantly.

Effective Tanks: Alistar, Amumu, Blizcrank, Cho'gath, Dr. Mundo, Galio, Garen, Gragas, Malphite, Maokai, Mordekaiser, Nasus, Nunu, Olaf, Rammus, Renekton, Shen, Singed, Xin Zhao

Junglers

Indicator factors:

α=0.1 β=0.3 γ=0.05 δ=0.05 ε=0.5 (see pg 11 for what they represent)

Purpose: These champions are the jungle controls of the team. They are never seen by the other team during the early stages of the game as they do not lane. They provide a very strong surprise element in early to mid-game ganks since they are invisible to the enemy team. Thus, being able to roam in the hidden parts of the map make them great for providing map awareness through wards and their main deciding factor is their roaming score.

Effective Junglers: Lee Sin, Shaco, Trundle, Warwick

Supports

Indicator factors:

α=0.5 β=0.05 γ=0.1 δ=0.25 ε=0.1 (see pg 11 for what they represent)

Purpose: These champions are supports to the team. Their main roles are usually healing teammates, providing buffs and debuffs. They provide main source of team advantage other than damage so they end up with a lot of assists. Their main money comes from creep kills so they must have a high creep score in order to have enough items to support their team.

Effective Supports: Evelynn, Heimerdinger, Janna, Karma, Kayle, Lux, Sona, Soraka, Taric, Zilean

α- *kill and assist to death ratio factor*   **β**- *ward placement score factor*   **γ**- *turret score factor*
δ-*creep kill score factor*   **ε**-*roaming score factor*

Results and Analysis

Overview

The purpose of the analysis is to test the performance of the new system as opposed to the performance of the old system. Since for each new season, each player's rating will begin at 1200, the two systems will be simulating between 0 to 10,000 games for 10,000 players that all start at the median rating of 1200. The simulation will give each player a random true rating so that there are players at all ranges of skill level. Then it will try to imitate how the real matchmaking system works by pairing ten players who are closest in rating together into a game. The outcome of the game will be determined based on the true ratings of the players on each team and a random factor to simulate the uncertain outcome in the team environment. Afterwards, the system will adjust the players' ratings with the Elo system and with the new system, and the plot of players with their current rating and their true rating will be shown after a specified amount of games.

In each simulation, each diamond shape is a player and the color of the diamond represent the true skill of the player with black being worst, silver being middle, and gold being the best. Multiple simulations will be done for each simulation parameter for consistency but only two will be shown in the results.

Results

Simulation parameters: Elo system, 10 games
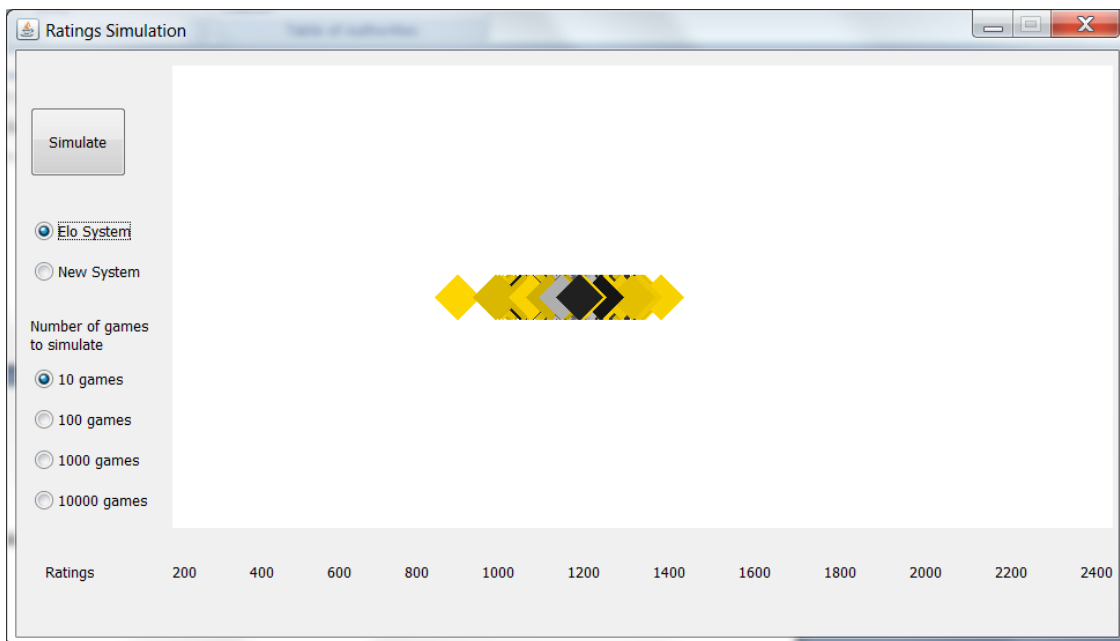
Figure 1: simulation 1 of Elo system after 10 games
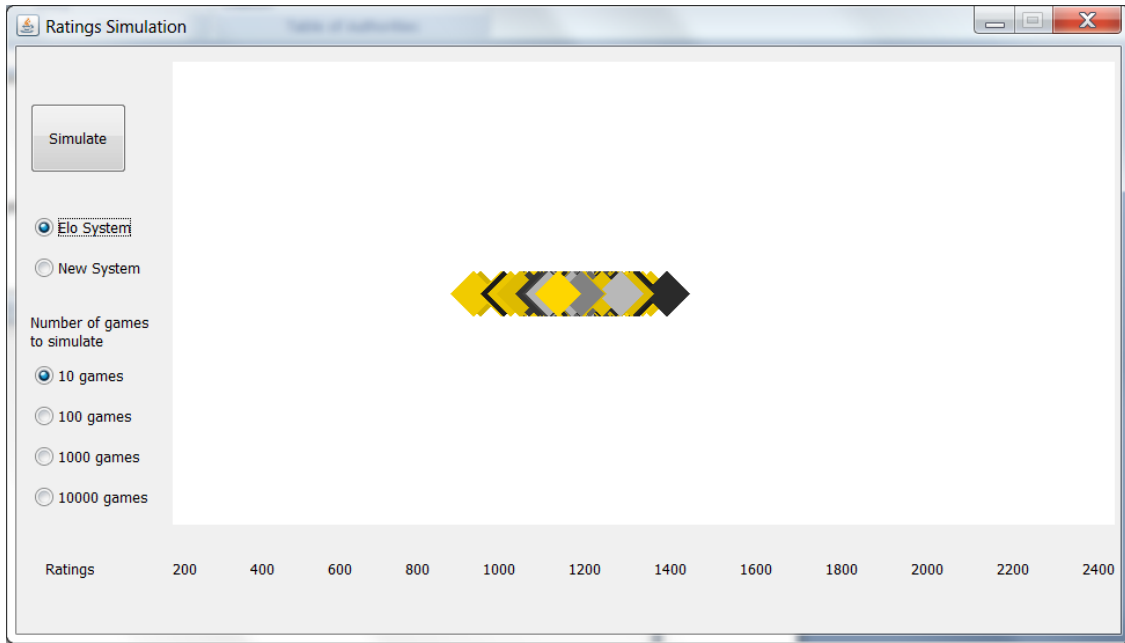
Figure 2: simulation 2 of Elo system after 10 games

Comments: As the simulation shows, after 10 games, the range of ratings is still very small since a player cannot move up or down too far in 10 games. However, it is very clear that some of the best players ended up on the lower end of the spectrum while some of the worse players ended up on the higher end of the spectrum.
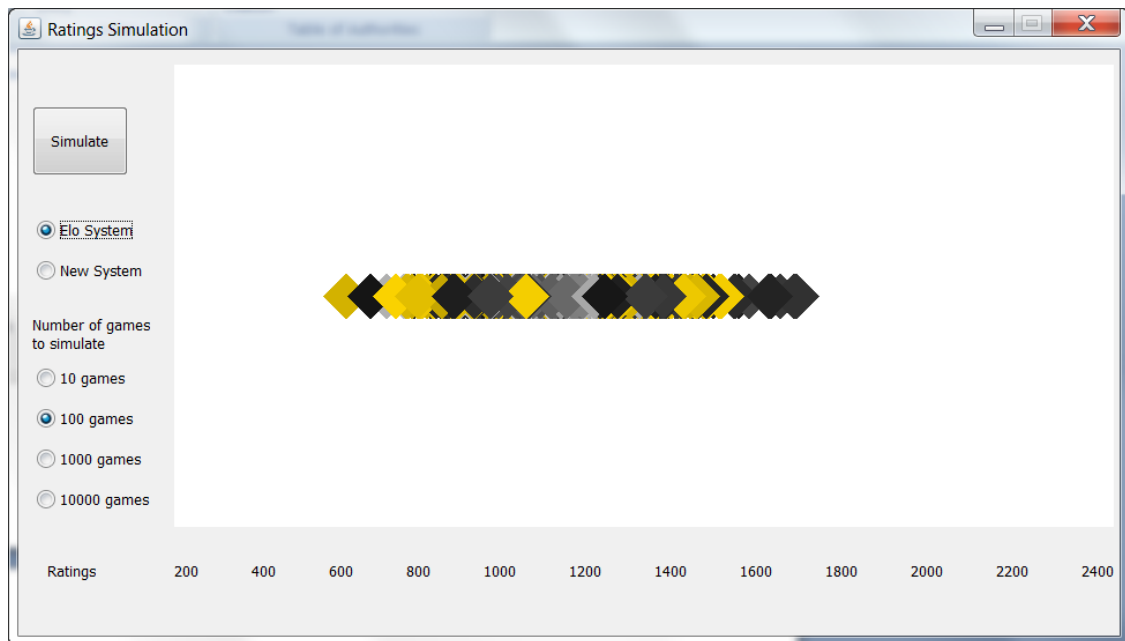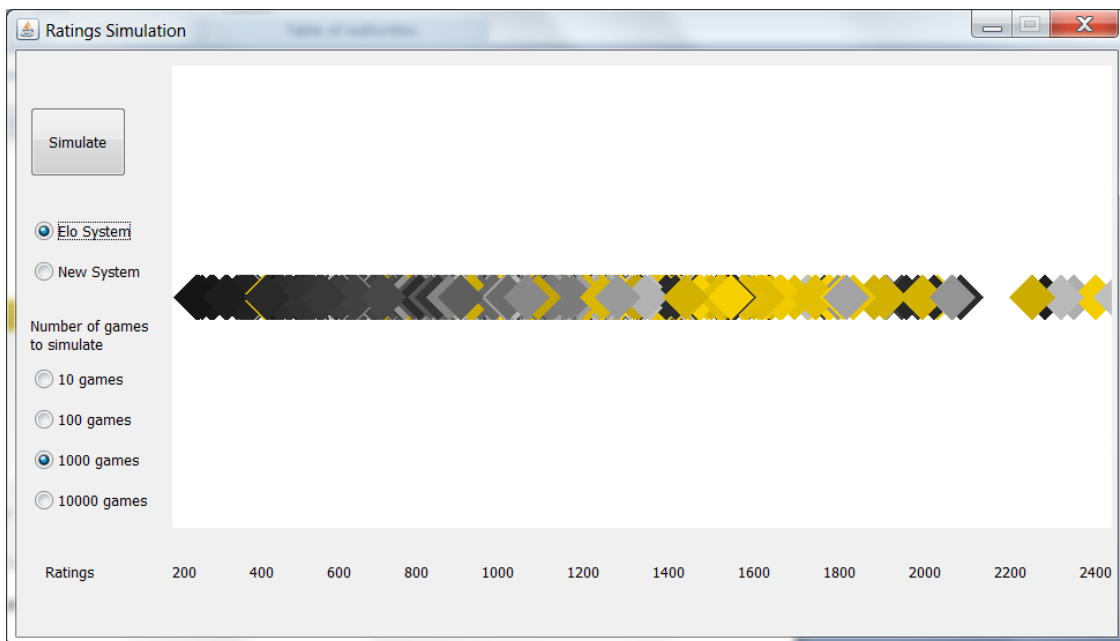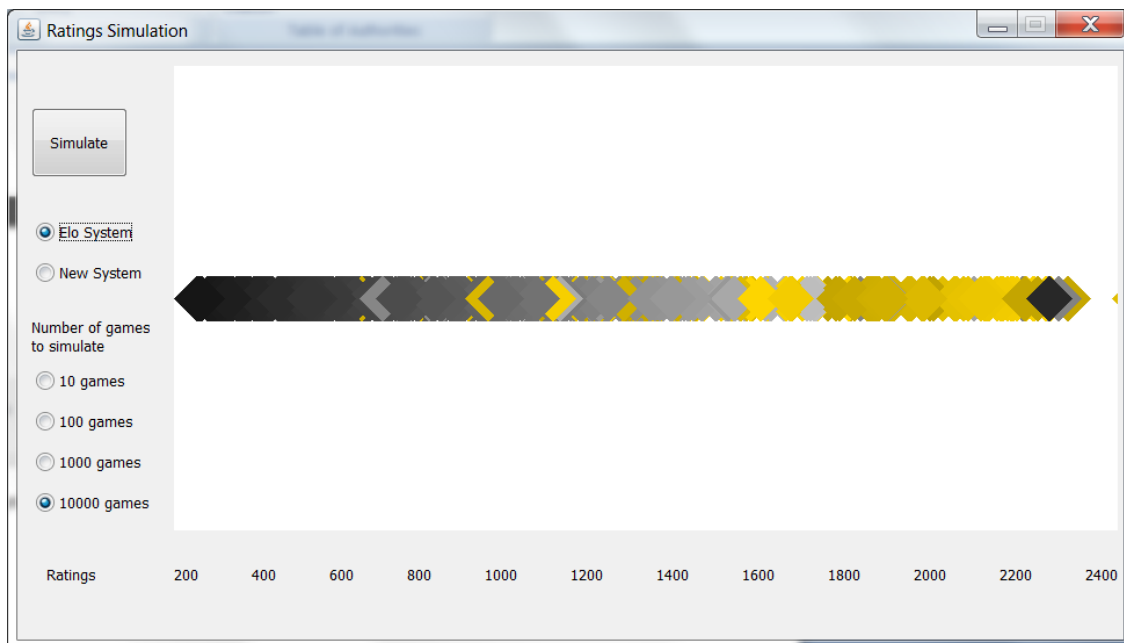
Simulation parameters: Elo system, 100 games

Figure 3: simulation 1 of Elo system after 100 games
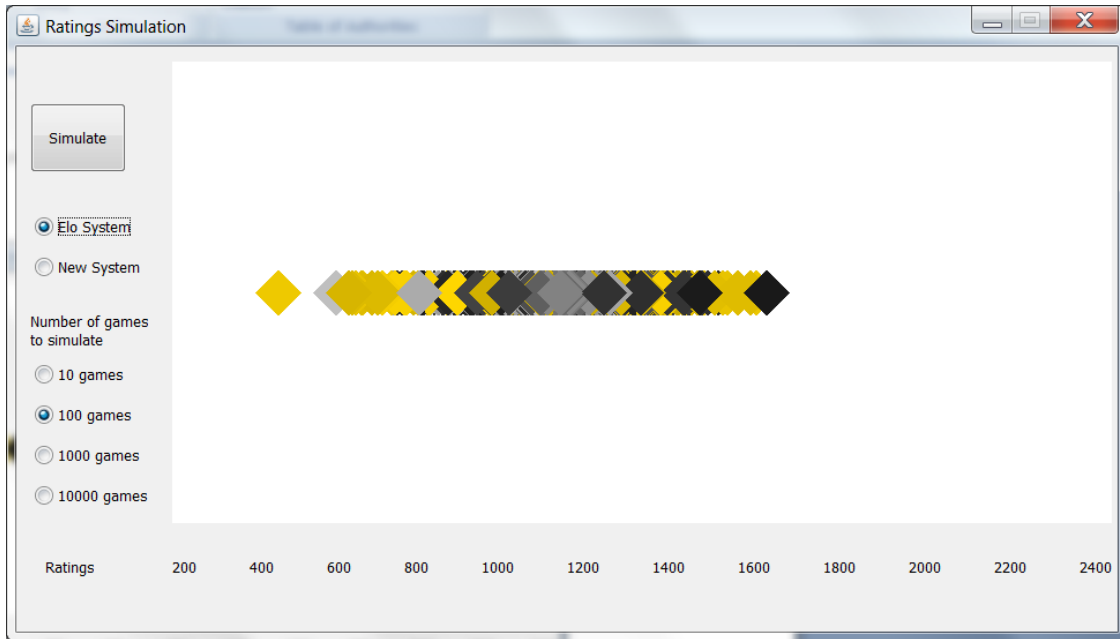
Figure 4: simulation 2 of Elo system after 100 games

Comments: After 100 games, the range of ratings is starting to spread out more. However, as clearly shown in the figures, a lot of good players are still on the low end of the spectrum while a lot of bad players are on the high end of the spectrum. In Figure 4, one of the best players, as represented by the gold diamond, is all the way on the very left side. This is an example of a good player being dragged down to the low end due to constantly being paired up with terrible teammates.

Simulation parameters: Elo system, 1000 games

Figure 5: simulation 1 of Elo system after 1000 games
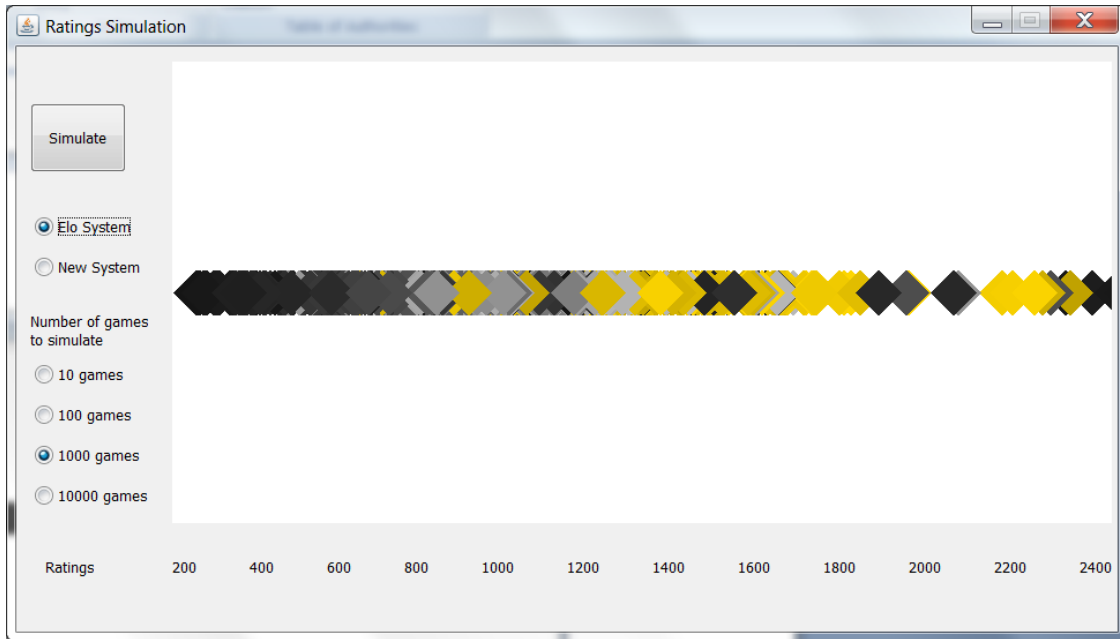
Figure 6: simulation 2 of Elo system after 1000 games

Comments: After 1000 games, the whole range of ratings is properly represented. Even though the spectrum is somewhat showing a gradient from black to silver to gold now, the same problem still persists. Many good players are stuck in the middle range, unable to get out.

Simulation parameters: Elo system, 10000 games

Figure 7: simulation 1 of Elo system after 10000 games
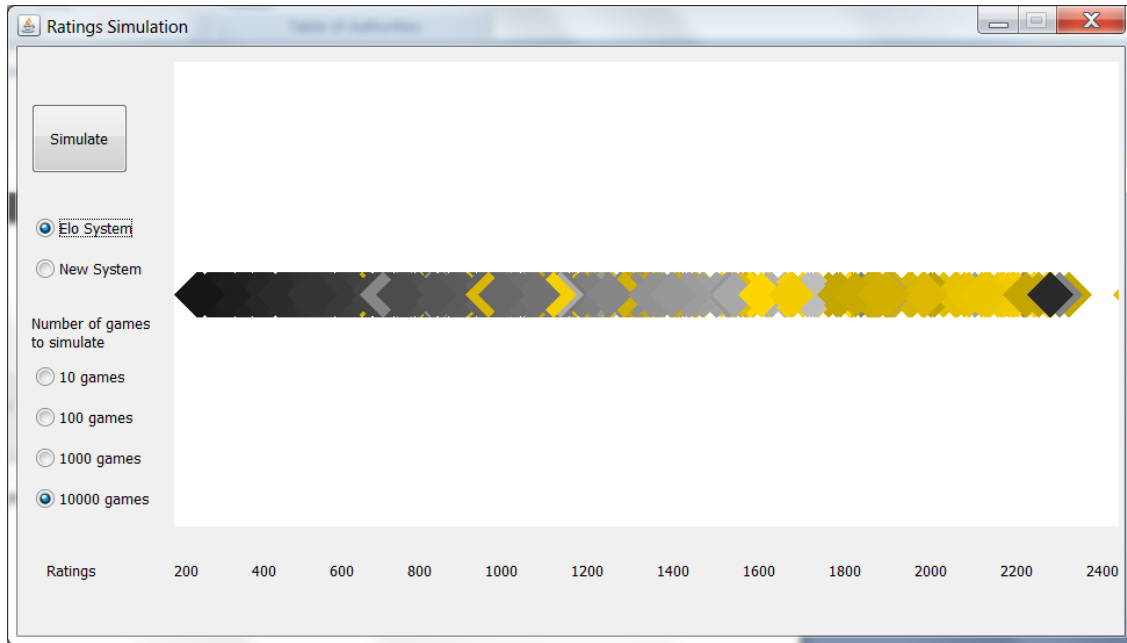
Figure 8: simulation 2 of Elo system after 10000 games

Comments: By the assumption of Elo, after enough games, each player should reach their respectively true rating. However, as we can see in the figures, even after 10000 games, there are still more than a few players who are clearly not at the ratings they should be in.

Simulation parameters: new system, 10 games
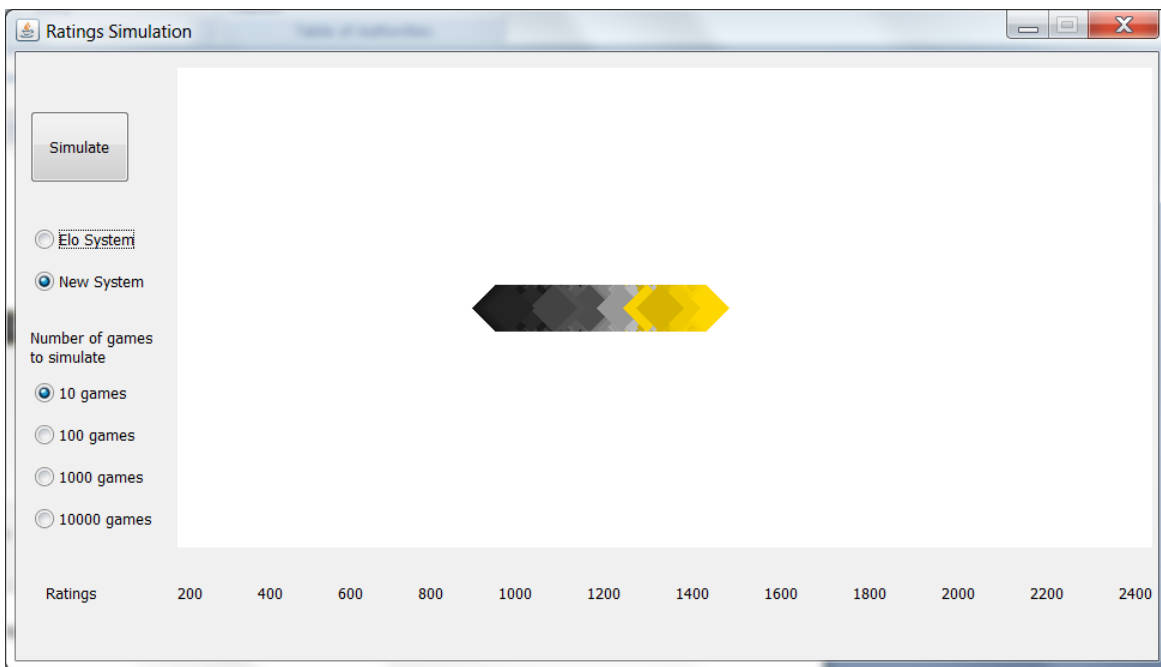
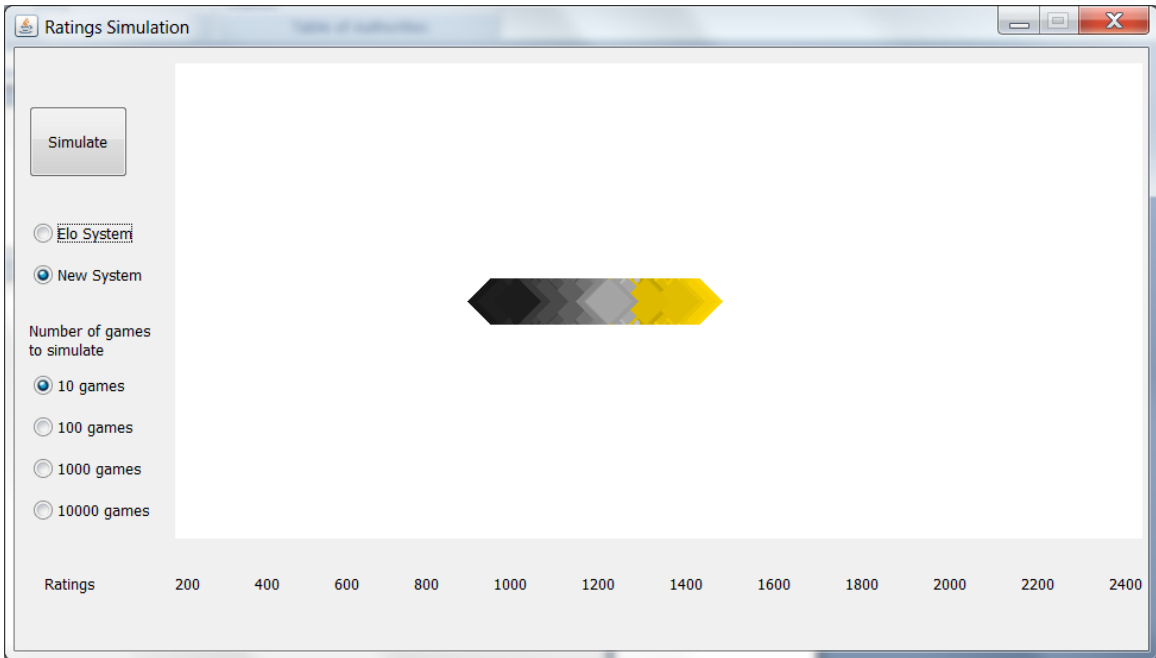Figure 9: simulation 1 of new system after 10 games

Figure 10: simulation 2 of new system after 10 games

Comments: Like the Elo system, the range of ratings is still small after 10 games. However, with the new system, we cannot observe any player who is not in his respective rating game even just after 10 games.
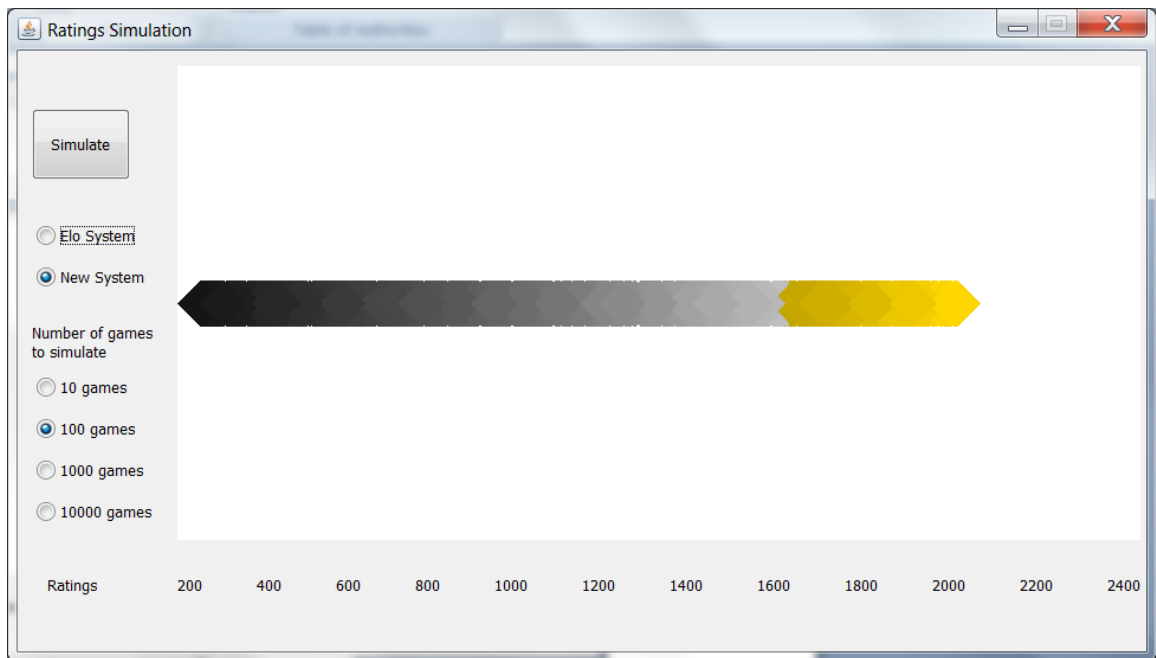
Simulation parameters: new system, 100 games
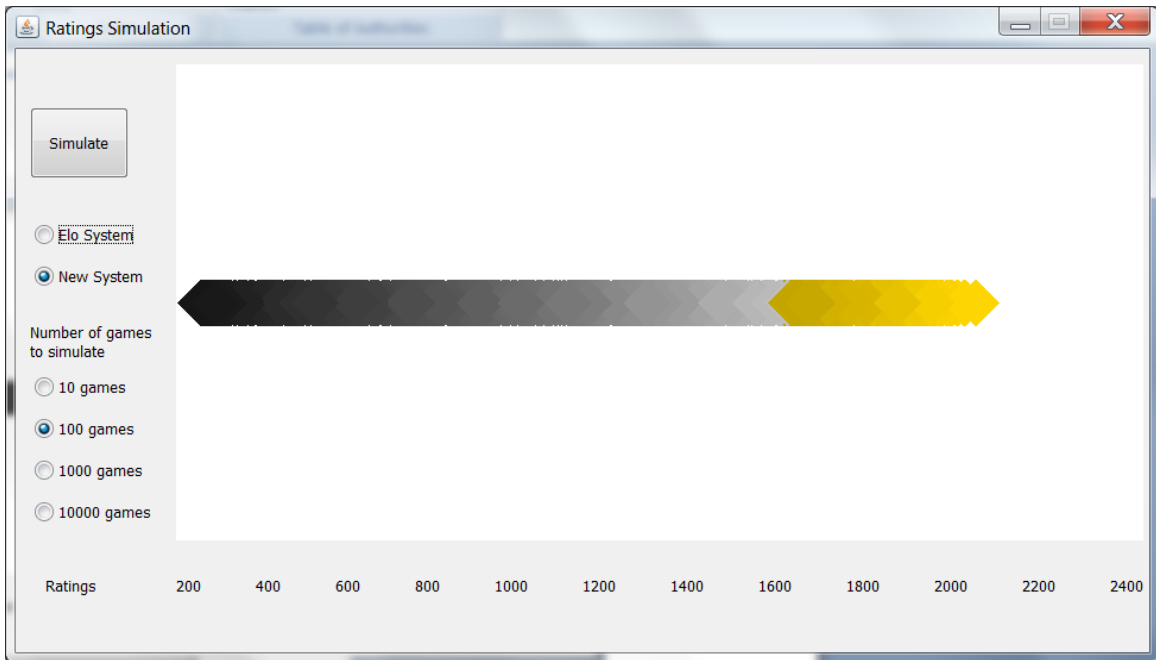

Figure 11: simulation 1 of new system after 100 games

Figure 12: simulation 2 of new system after 100 games

Comments: As we can see, even just after 100 games, the rating spectrum exhibits an almost perfect gradient from black to silver to gold. This indicates that almost all the players are in their respective rating bracket and no one should have a one-sided game.
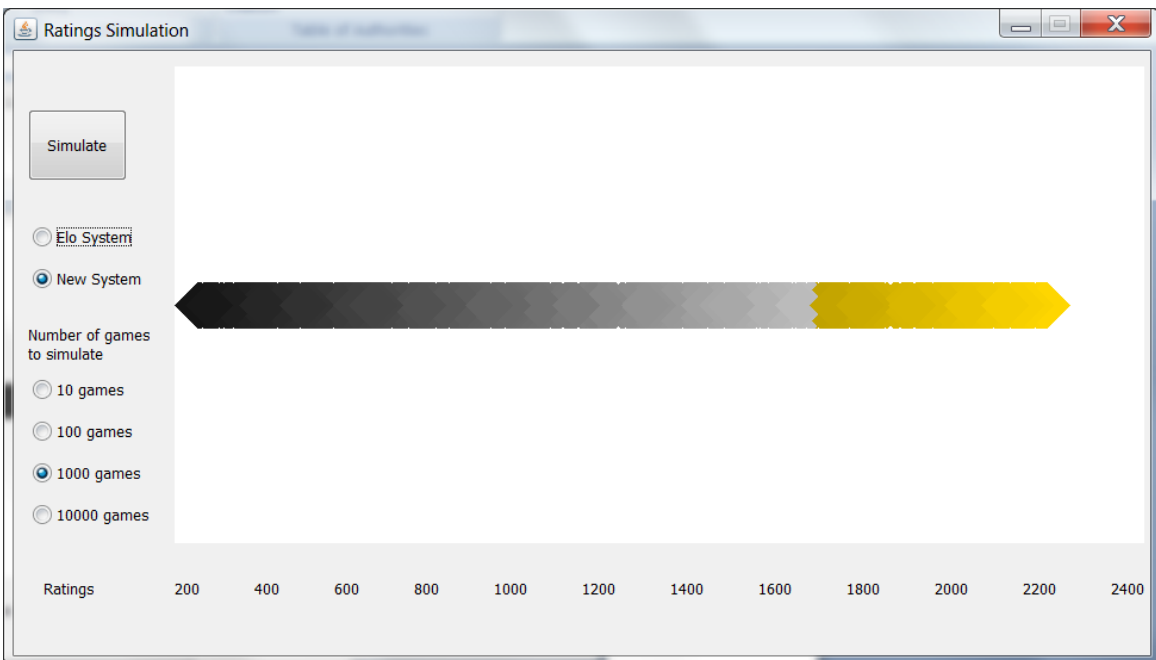
Simulation parameters: new system, 1000 games

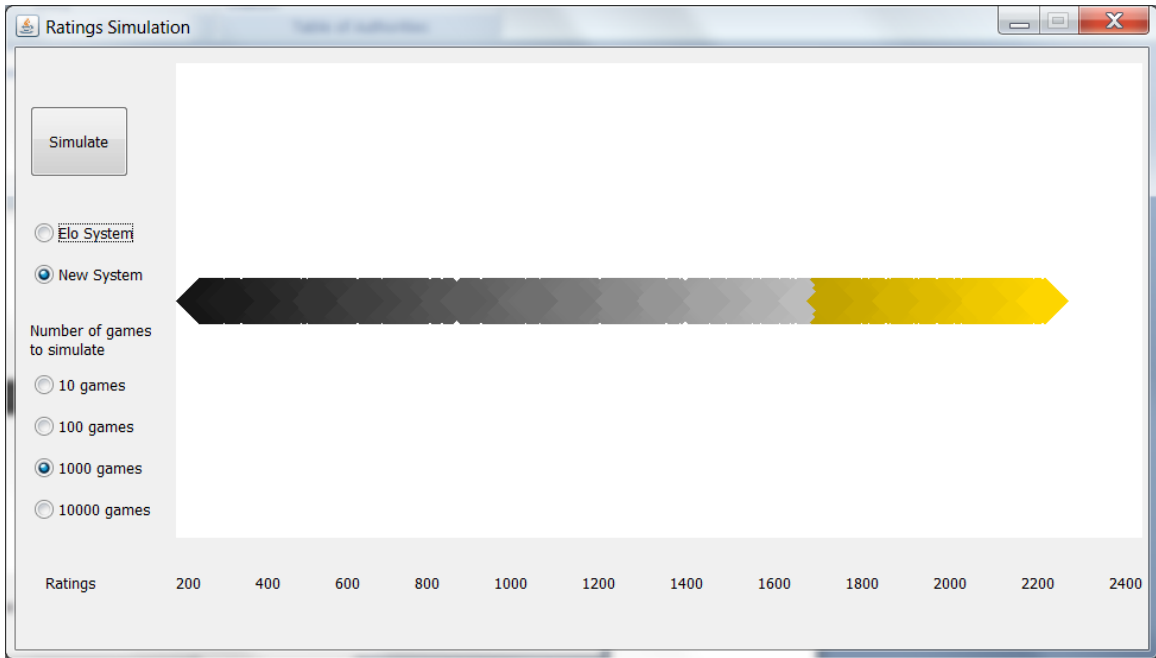Figure 13: simulation 1 of new system after 1000 games

Figure 14: simulation 2 of new system after 1000 games

Comments: Other than the range being more spread out because of more games played, this simulation shows a perfect gradient of the rating spectrum like the 100 games spectrum. It seems that 1000 games are enough for every player to reach his true skill level.

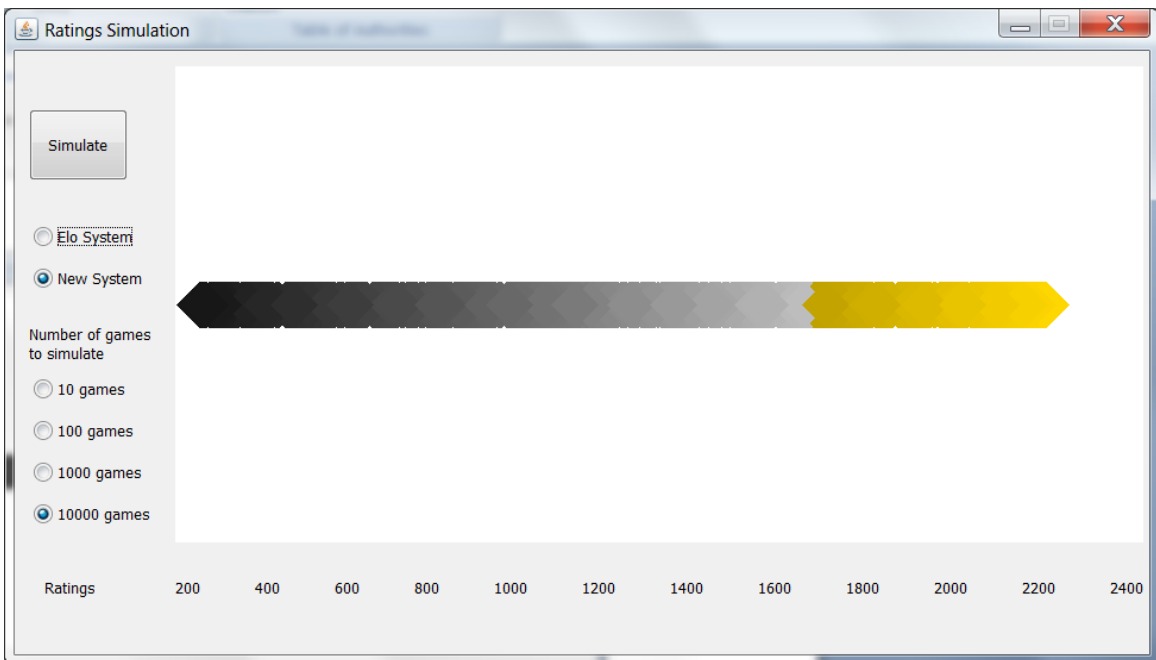**Simulation parameters: new system, 10000 games**

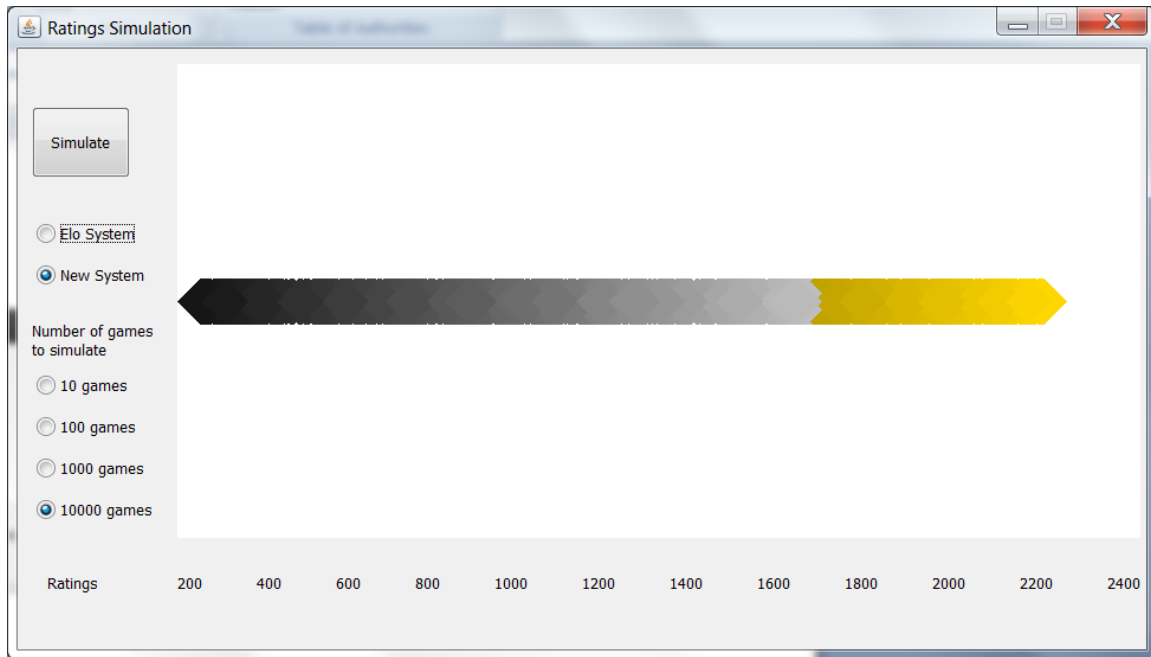Figure 15: simulation 1 of new system after 10000 games

Figure 16: simulation 2 of new system after 10000 games

Comments: This spectrum exhibits no significant difference than the 1000 game spectrum. This further justifies that 1000 games is a big enough number for every player to reach his true skill level.

Conclusion

As shown by the simulation results, the new system exhibits an overwhelming advantage over the Elo system for League of Legends. For the Elo system, even after 10000 games played between the players, there are still a significant amount of gold players stuck between the middle ranges. Those players most accurately represent the players who are currently experiencing the "Elo Hell" and are having trouble getting out due to unlucky pairings with unskilled teammates. However, with the new system, just after 100 games played between the players, there does not seem to be any situation where a player ends up in a rating bracket he/she does not belong in. Clearly, because of all the factors taken into consideration by the new system, a player reaches his/her true skill rating quicker and easier than the Elo system. The source code of the algorithm is easy to implement and will be given upon request. I suggest testing the new algorithm on the Beta server with a real player base to further evaluate the advantages of the new system.