

Matchmaking Series:

Matchmaking for MP Ranked Play

Overview

Ranked Play is Call of Duty's competitive ranked Multiplayer mode. In Ranked Play, players compete in 4v4 matches to earn Skill Rating (SR) and progress through 7 Ranks: Bronze, Silver, Gold, Platinum, Diamond, and Iridescent, with the Top 250 players in Iridescent being highlighted on a public leaderboard. Ranked Play matches feature the same weapons, restrictions, maps, and modes used in the Call of Duty League.

Everyone in Ranked Play has an individual SR that represents their skill journey in Ranked Play and qualifies them for one of the 7 Ranks. SR is earned when you win, and deducted when you lose – the amount earned or lost is influenced by personal performance and the margin of victory. Each player's SR is closely linked with, but not identical to, their actual measured skill level from their Ranked Play career (to ensure that players make their way to a Rank that is representative of their underlying skill). The SR system is tuned to be engaging and rewarding, but also be representative of a player's skill at the highest levels of competitive play to clearly separate the best from the best. This paper will go into detail about how the SR system works.

It's also important that players are put into matches with and against players at the same or similar Rank as often as possible. There are a handful of different systems that accomplish this that are exclusive to Ranked Play and not present in standard Call of Duty Multiplayer matchmaking. These Ranked Matchmaking systems will be further detailed in this white paper.

Terminology

Matchmaking	The process of determining which players play each other and how teams are balanced within a lobby.
SR	SR (or Skill Rating) is a visible representation of the player's skill journey in Ranked Play. SR is gained after wins, and deducted after losses. The amount of SR gained or lost is closely linked to the player's Raw Skill.

Dedicated Server	A game host server running in a data center.
Ping	The time taken for a network packet to make a round trip from the game client to the dedicated server and back.
Delta Ping	The difference between a player's lowest ping data center and their ping to any given other data center.
Lobby	A collection of players and parties that are in the process of being assembled to play a match, in the process of playing a match, or in the process of finishing a match.
Raw Skill	A single value representing a player's performance relative to the rest of the player population. This is often casually known in the industry as MMR.
Skill Percentile	A value which represents where in the population a player's Raw Skill lies.
Skill Decile	A bucketed view of skill percentile. A player in the 0.0 skill decile is in the bottom 10% of players and a player in the 0.9 skill decile is in the top 10% of players.
Rank	The player's Ranked Play Rank is determined by the amount of SR they currently have. There are 7 Ranks: Bronze, Silver, Gold, Platinum, Diamond, Iridescent. The Top 250 Rank is considered a part of Iridescent for the purposes of Matchmaking.
Skill Disparity	The difference between the highest and lowest Skill Percentile of players in a party or lobby.
Rank Disparity	The difference between the highest and lowest Rank of players in a party or lobby. A party with a Gold player and a Bronze player would have a Rank Disparity of 2.
Core Multiplayer (Unranked)	Non-Ranked Play modes in which players don't earn or lose SR and with less gameplay and matchmaking restrictions.

Review of Matchmaking

Matchmaking in multiplayer games is the process of determining which players who are actively looking for a match should play each other. It also comprises decisions about how those players are divided into teams in a balanced manner. In a previous white paper [\[1\]](#) about the matchmaking system in *Call of Duty* we go into great detail about what makes this a complicated problem and how we solve it in a way that provides a consistently fair

experience for our players. Since this paper is primarily concerned with *Call of Duty's* competitive Multiplayer mode we will summarize a few details necessary to understand Ranked Play matchmaking. Please refer to the earlier white papers for a deeper presentation of matchmaking as a whole.



We balance across a number of dimensions when forming matches. Out of these the three we have discussed in most detail are players' connection quality (also known as "ping" or "delta ping") to potential lobbies, their search time, and their skill relative to the rest of the players in a lobby. We carefully choose how we balance between all of our matchmaking priorities based on player feedback and experimental evidence. This balance varies between game modes in order to provide the best experience. In Core Multiplayer (Unranked) Multiplayer modes we prioritize faster search times and low latency so that players can quickly get into responsive lobbies [2]. Ranked Play lobbies prioritize competitive fairness and integrity and we leverage longer search times to build lobbies with players of similar Rank and skill.

Matchmaking for Ranked Play

Call of Duty's Ranked Play matchmaking system is a specially-tuned version of the one described in our previous white papers [1] [2]. This section details how it differs from the general matchmaker outlined there and explains the motivation for those changes.

There are a few parts of Ranked Play matchmaking that are actually advantageous to the matchmaker. Smaller games of 4v4, instead of the common 12 player games in Core MP, mean we will make more matches with the same number of searches, increasing the matchmaker's space of options. This also means parties are of smaller sizes and therefore the complexity of party matchmaking is mitigated slightly, though the presence of more parties on average makes the matchmaking problem more difficult. As opposed to Core MP (Unranked), Ranked Play matches do not allow players to join in progress once a match has started. This means all searches can be dedicated to finding the highest quality new match, instead of simultaneously balancing the value of a new match against filling existing matches. Ranked Play is also limited to a single playlist, which means the player population is not split, as it is in Core MP. These advantages prove vital, as matchmaking for Ranked Play has a variety of additional complexities.

Importantly, while the game UI presents the Top 250 players as a distinct eighth Rank, there are only seven from a matchmaking perspective. The Top 250 players are considered as being part of the Iridescent Rank as, by definition, the Top 250 is a very small group.

Longer Search Times

As outlined in the skill white paper [\[1\]](#), the general-purpose matchmaker used in Core MP (Unranked) is tuned to place players into full, low-latency lobbies quickly—secondarily optimizing for skill, voice chat preferences, etc.

Ranked Play matches have a different set of priorities. Unlike other matchmaking outcomes (e.g. high latency), a "worse" or longer search time doesn't negatively impact match quality. When forming Ranked Play matches we purposefully allow longer search times to improve performance along the metrics that are important to competitive integrity and match quality. Later sections on latency, SR, and skill explore how we take advantage of this additional time.

Figure 1 shows the difference in search time between non-Ranked Play multiplayer and Ranked multiplayer modes. In Ranked Play, the median search time is twice as long (50ms vs. 25ms) to form a match. The tail end of the Ranked Play distribution waits significantly longer to find a high-quality match – this is a consequence of design decisions which set a lower-bound on acceptable quality for fair competitive game play.

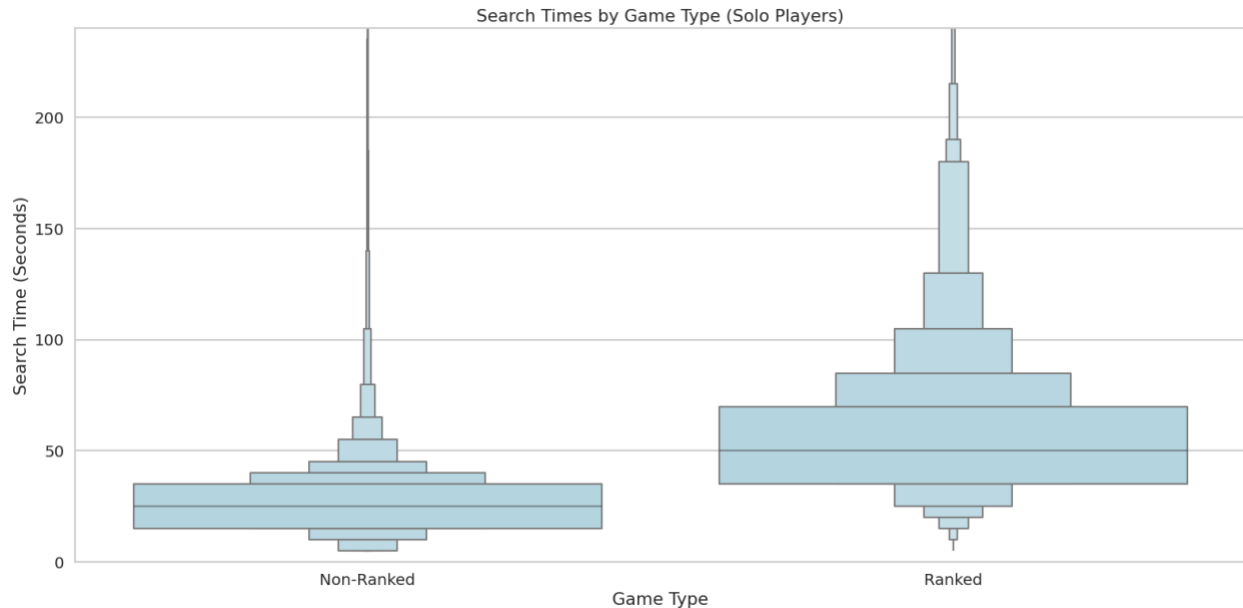


Figure 1. Letter-value plot of time spent searching for a match across non-Ranked Play and Ranked Play modes.

Who are the players experiencing long search times? Some are searching in low-population areas, others might be high-skill or placed in one of the upper Ranks where there are naturally fewer players available to match with. We went into some detail in the skill white paper [1] about how, in non-Ranked Play, we ensure consistent search times for players across the skill distribution. While we leverage the same strategy of matchmaking on skill percentile instead of Raw Skill described there, Ranked Play is complicated by the presence of SR and Ranks. As players enter higher Ranks their available population gets smaller and matchmaking constraints therefore become more difficult to satisfy. **Figure 2** shows the relationship between search time and Rank and **Figure 3** shows the correlated relationship between search time and skill percentile. Where search times are consistent across the skill distribution in non-Ranked Play they increase for higher-skilled players in Ranked modes.

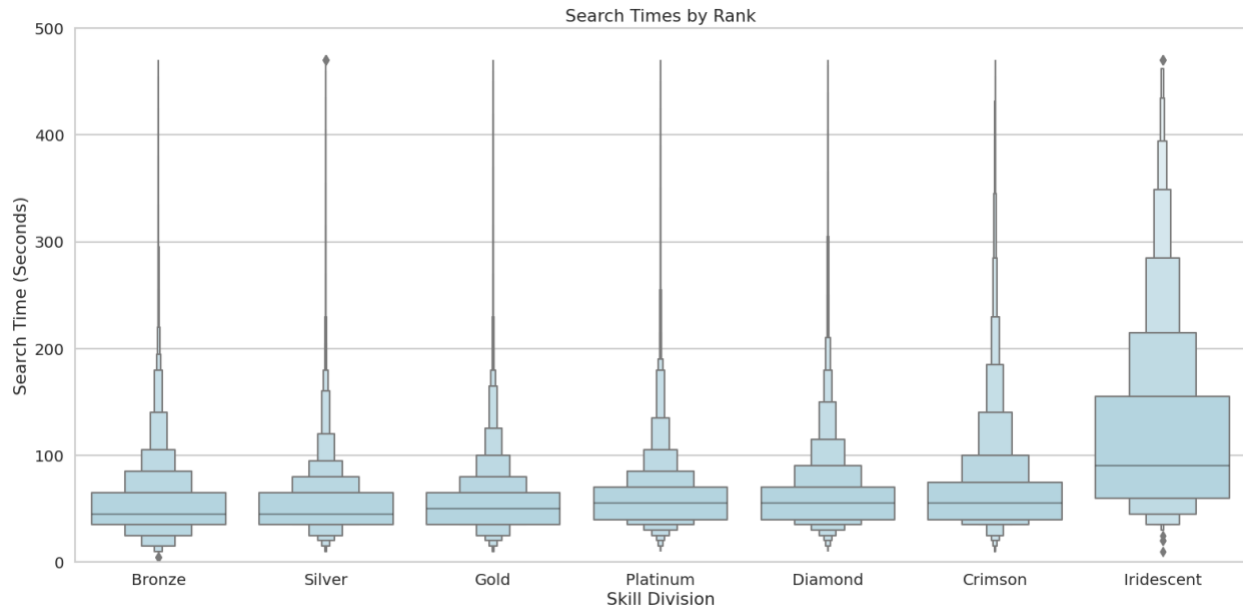


Figure 2.
The distribution of search times in seconds by each of the 7 Ranks.

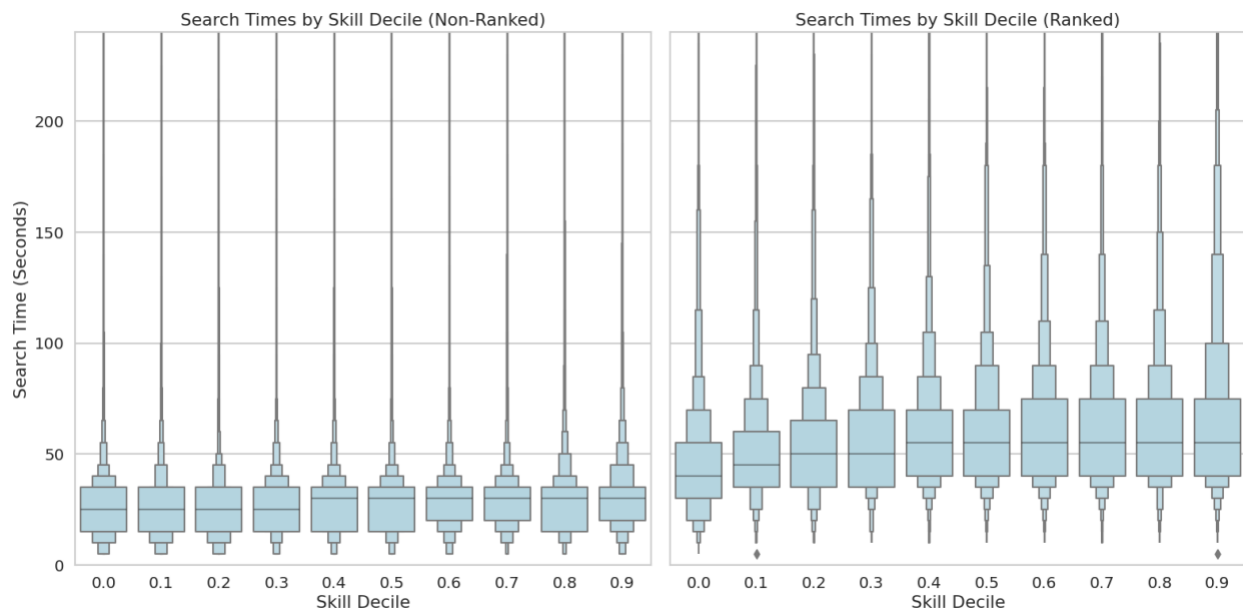


Figure 3.
The distribution of search time by skill decile in non-Ranked Play (on the left) and Ranked (on the right)

Ensuring Connection Quality

Network latency is a major factor in the quality of a Multiplayer lobby. The first white paper [2] in this series examined how the matchmaking heuristics prioritize forming low-latency

matches. Ping is important across all game modes, especially in Ranked Play where a poor connection can make the difference between a fair and unfair lobby. Because the Ranked Play matchmaking population is smaller than that of Core MP (Unranked) it is fundamentally harder to find a group of players who have optimal connections to the same data center. Part of the additional time spent searching is in waiting for players with compatible network connectivity to enter matchmaking.

Figure 4 shows that both the median player and the tail-end player have better Delta Ping outcomes in ranked matches than in non-Ranked matches, and most players match into lobbies below 10ms of Delta Ping.

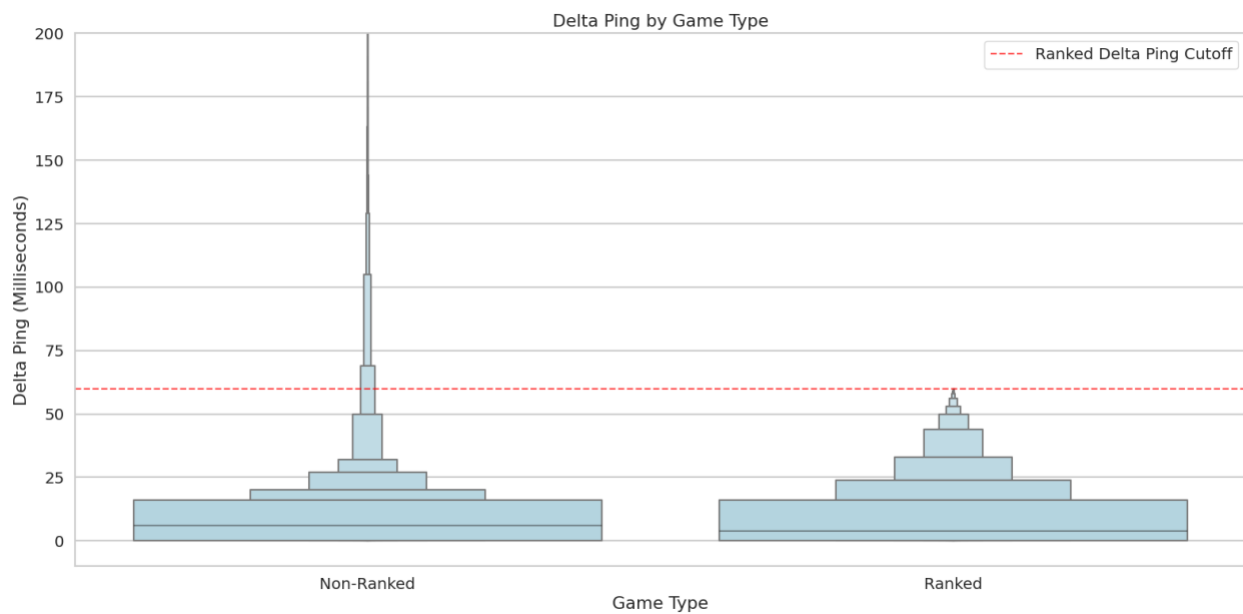


Figure 4.
The distribution of Delta ping in both non-Ranked and Ranked modes.

Additionally, Ranked Play matchmaking enforces hard constraints that aren't used in Core MP (Unranked). For example, in Ranked Play, we don't place players in a lobby hosted in a data center that has much worse latency than their ideal data center. The impact of this constraint is illustrated in **Figure 5**, where we see a slight, but tolerable, increase in Delta Ping for players in higher Ranks because of the limited matchmaking population.

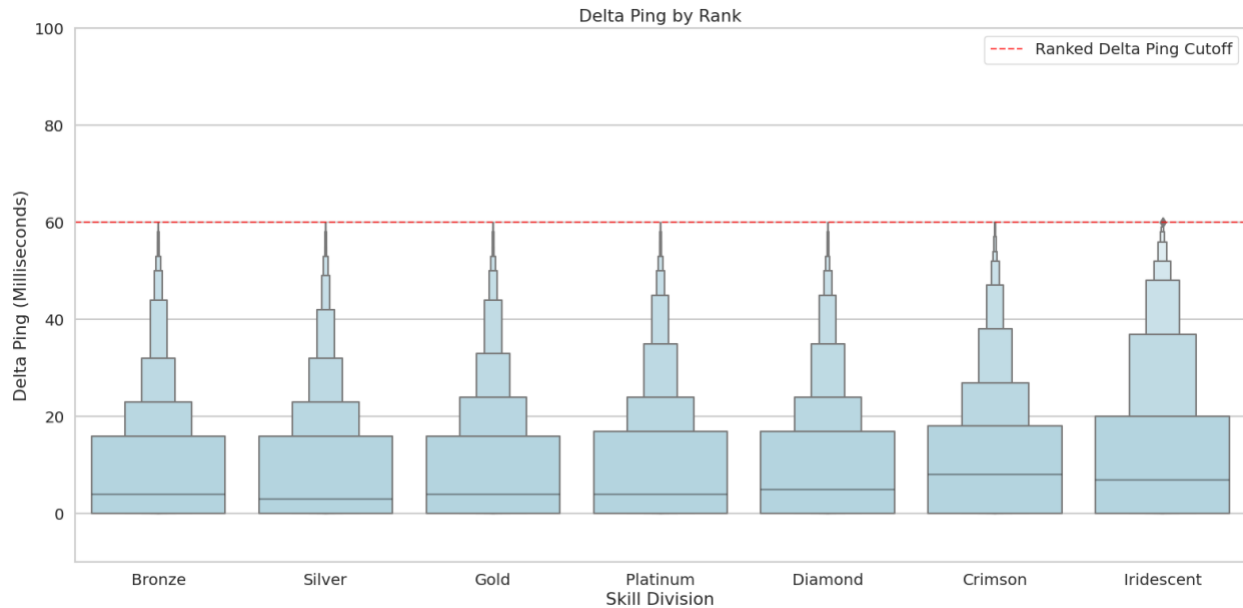


Figure 5.
Letter-value plot showing the consistent Delta Ping outcomes for players across all Ranks.

The Effect of Parties on Matchmaking

Imagine two players, one in the bottom 10% of skill in Chicago and another in the top 10% in Berlin, looking for a match – it’s obvious that we should try to avoid putting them into the same match. Not only does the skill disparity mean the player in Chicago is likely to have a poor experience, but it would also be difficult to find a server that could give both players good connectivity. The best matchmaking decision in this scenario would be to find other, more appropriately matched players or to keep searching and wait for some to come online.

Generally, a matchmaking system will form its best (lowest latency, tightest skill, etc.) matches when it builds them out of solo players. Consider the previous example if the two players were in a party together. No matter how we fill out the rest of the lobby, its skill disparity has a lower bound of 80% and at least one of its players will have sub-optimal connectivity.

Parties set a lower bound on the quality of a lobby by constraining the inputs the matchmaker has to work with. This section discusses how we attempt to form good matches in spite of that and how we decide which parties are unacceptable within the design constraints of a competitive Ranked Play game mode.

Fair Matchmaking for Disparate Parties

The social aspect of *Call of Duty* is one of our highest priorities. In Core MP (Unranked) players may party with anyone. Our skill white paper [1] has more details about how we attempt to form fair and high-quality matches even when parties are highly disparate. To ensure fairness in competitive matchmaking, we limit which Ranks players can be in when they party up with each other as described in **Table 1**. As more players join a party the set of allowed Ranks may narrow – for example if a Gold player forms a party with a Diamond player, they will only be able to invite other Gold, Platinum or Diamond players.

Player Rank	Allowed Ranks in Party
Bronze	Bronze, Silver, Gold, Platinum
Silver	Bronze, Silver, Gold, Platinum
Gold	Bronze, Silver, Gold, Platinum, Diamond
Platinum	Bronze, Silver, Gold, Platinum, Diamond
Diamond	Gold, Platinum, Diamond
Crimson	Diamond, Crimson
Iridescent (including Top 250)	Crimson, Iridescent

Table 1.

Party membership restrictions on Ranks.

Rank Matchmaking Rules

The Rank rule controls which Ranks are allowed to play together over the lifetime of a search. The tightest possible match would be a lobby with no Rank disparity—a lobby entirely made up of Platinum players, for example – and for the first phase of a new search the system will attempt to form such a match. Because population size varies geographically and over the course of the day, we will expand the range of eligible Ranks, if there are not enough players available to create a high-quality match. **Figure 6** shows how this range backs off over time and the manner in which the backoff is tuned for each individual Rank.

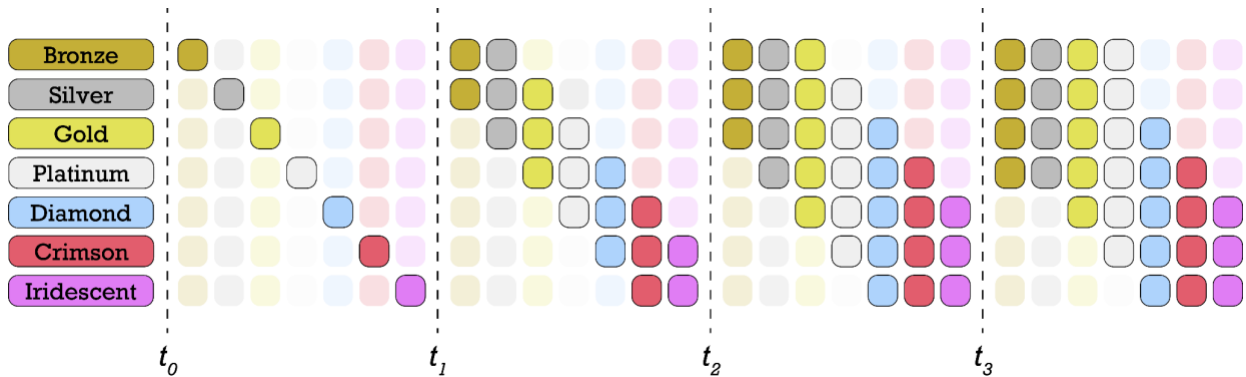


Figure 6.

Visualization displaying how Rank Disparity constraints back off over time during Ranked Play matchmaking. At first (from time t_0 to t_1), the matchmaker attempts to form high-quality lobbies with players from a single Rank. After a configurable time has elapsed, the Rank Disparity constraints are loosened. This loosening happens up to three times, at t_1 , t_2 and t_3 . Each phase is long enough to provide the matchmaker an opportunity to form a quality match with that Rank Disparity.

This should start to answer a common question from players – why there might be players one, two or even three Ranks higher or lower in their lobby. Cross-Rank parties and low matchmaking populations sometimes necessitate backoffs like these, but they don't mean lobbies are necessarily unfair. One of the benefits of tracking SR and Raw Skill separately is that we can place similarly skilled (in terms of Raw Skill) players in lobbies together even if they are in different Ranks. This helps ensure that everyone has a fair chance to compete and a later section on skill rules explains how we leverage skill to form lobbies that are fair and meet our bar for competitive integrity.

SR Matchmaking Rules

One of the matchmaker's core concerns in forming Ranked Play matches is finding players with similar Rank and SR. Before this can be fully understood, what SR is exactly should be considered.

What is SR?

SR (short for "Skill Rating") is a visible value that represents each player's skill and progression in in *Call of Duty* Ranked Play. This value serves 2 distinct purposes:

- To provide players with a visual representation of their skill
- To provide players with a sense of progression in Ranked Play

These two properties are fundamentally at odds with one another, but both are very important.

If SR was purely a skill metric, many players would gain very little SR from match to match as most players don't see their Raw Skill improve very much over the duration of a Season. This would result in an unrewarding experience and not match player expectations of being able to improve in a competitive ranked system. To allow for this sense of skill progression, all players start in Bronze Rank and gain SR to climb toward their Target SR (as determined by their Raw Skill). This makes the mode much more compelling and provides players a reason to come back to Ranked Play each season to see how far up the Ranks they can make it.

The exact details of SR change from game to game, as we continue to improve the experience for our players. There are a few fundamental elements, however, that have remained consistent since SR was introduced:

- All players have a Target SR. This is essentially a direct translation of how a player's skill percentile correlates to a SR and Rank.
- All players have a Current SR. This is the value shown to players, which will trend toward (and in some cases surpass) the Target SR.
- SR is gained when players win.
- SR is lost when players lose.
- When a player wins, we move them toward their Target SR as a function of how far their Current SR is from their Target SR, and based on how they performed in that match considering the skill of their opponents.

The exact tuning here has changed over the years, but this system is always tuned such that players who participate with Ranked Play consistently will eventually find their Current SR hovering around their Target SR. While this does take quite a few games, the value of a win will almost always outweigh the impact of a loss, until you have surpassed your Target SR. As we outline below, skill percentile is still used in matchmaking in Ranked Play. Our approach to SR ensures that even if a player is always in a perfectly tight match, they will progress to their Target SR over enough games.

Unsurprisingly, the very best players in the world don't lose very often. It's not uncommon for our CDL Pros and players in the Top 250 to win over 80% of their Ranked Play matches. If unmanaged, these lopsided win rates by our best players can lead to SR inflation and a SR system that rewards playtime more than skill. To manage this, players who see their Current SR far exceed their Target SR will start to earn gradually less SR for wins, and may even start to see larger SR deductions after losses. This is done so that the best of the best must

maintain their high win rates to continue to climb, and ensures that Ranked Play rewards both a combination of skill as well as sustained playtime over the course of each Season.

How is SR used in Matchmaking Rules?

Similar to other matchmaking rules, Ranked Play matchmaking searches begin with a small target SR disparity and then gradually expands the range of what SRs are acceptable over time. Because of the Rank disparity rules described in the preceding section there are hard limits to how far target SR disparity can widen. **Figure 7** shows how the matchmaker performs in forming lobbies for players in various Ranks by considering the SR of other players in their matches. **Figure 8** illustrates the impact of parties on this matchmaking dimension and shows relatively better performance for solo players.

Max SR in Lobby by Player Rank

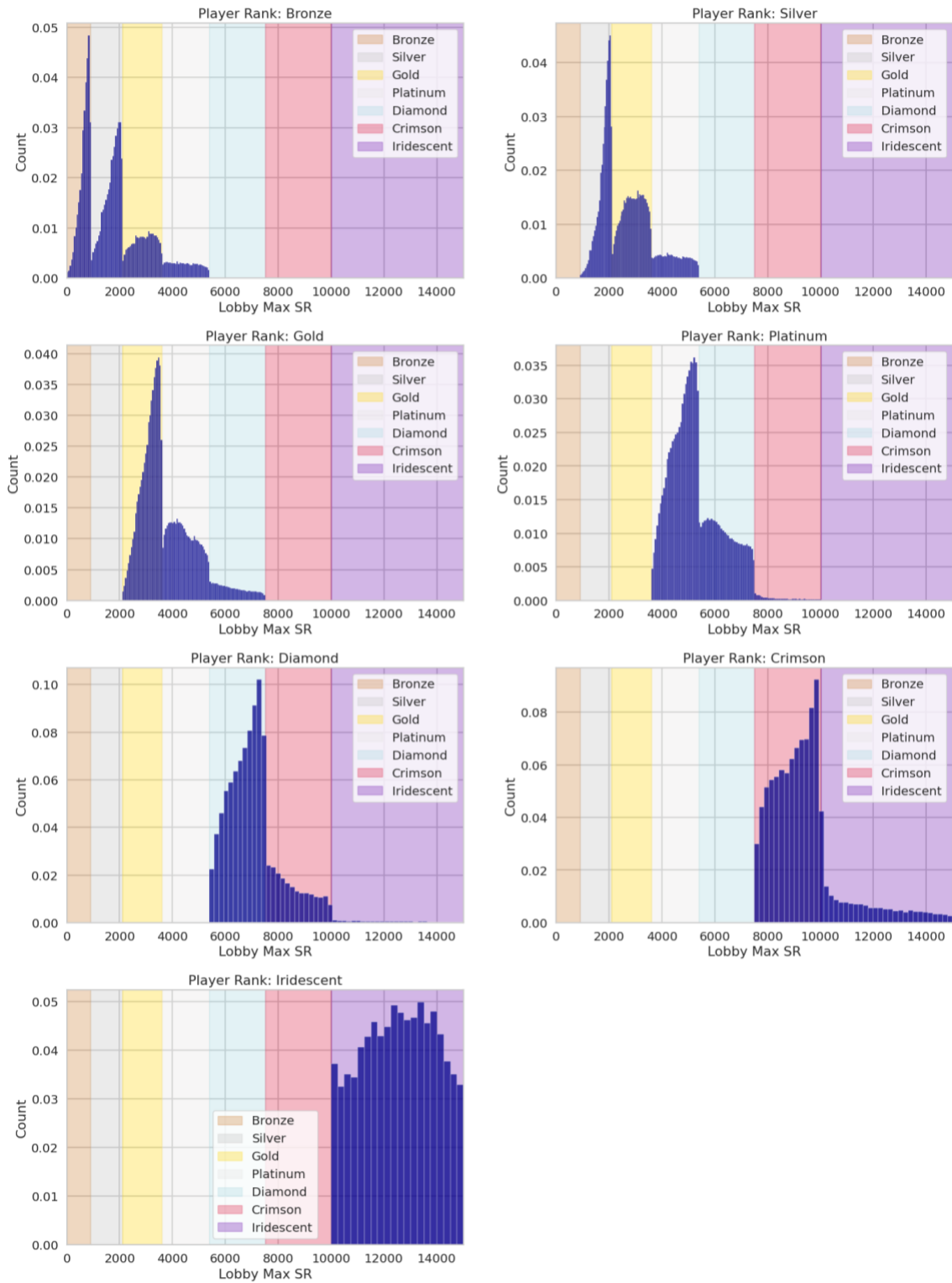


Figure 7. Histograms showing the distribution of the maximum SR that players in each Rank see in their lobbies.

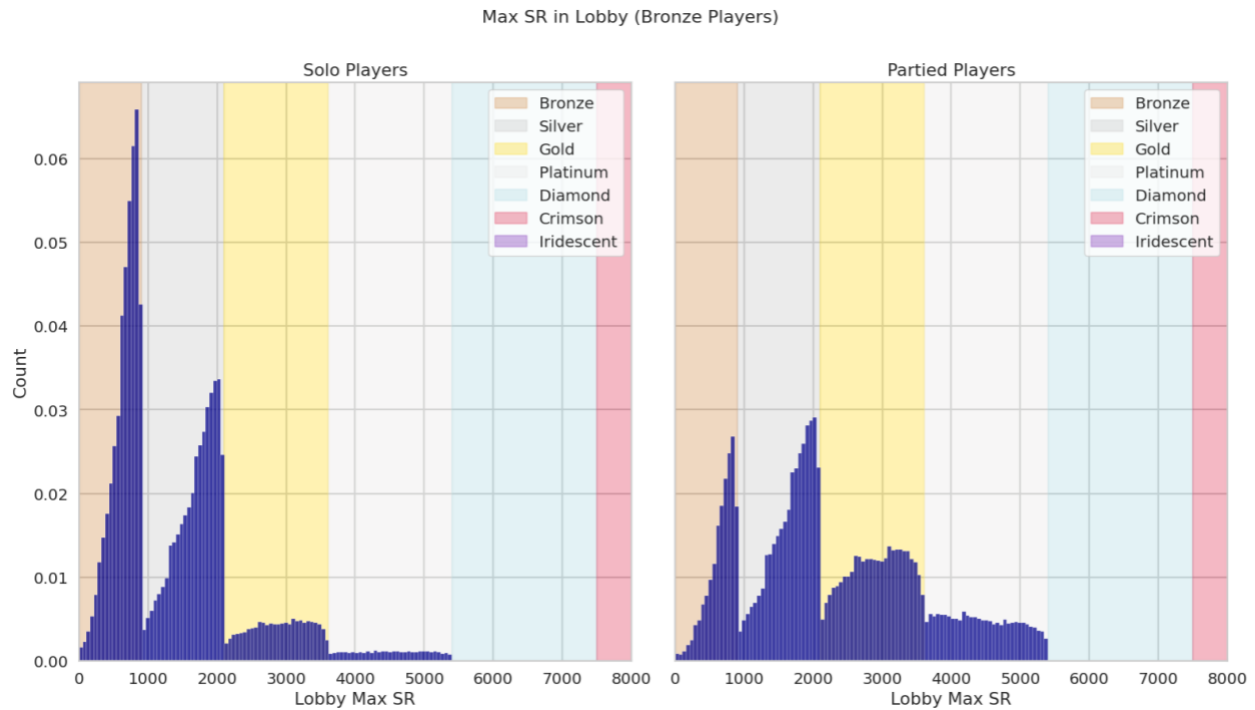


Figure 8. Histograms comparing matchmaking performance for solo and partied players in the Bronze Rank. Solo Bronze players are much less likely to see Gold or Platinum players in their lobbies.

Raw Skill Based Matchmaking Rules

Considering players' Raw Skill, in addition to their SR, is critical to form fair and competitive matches. While a player's SR always trends toward their Target SR, it is not always predictive of outcome. There are a few reasons for this, but the major ones are: all players start at the same SR value in the Bronze Rank, and some players drop a Rank (or more) when a new season begins. This means matching on skill as outlined in our second whitepaper [1] is as important in Ranked Play as it is in Core MP (Unranked). To facilitate a more competitive environment, search times are prolonged to ensure lower skill disparity matches than in Core MP, though the technology involved is essentially identical.

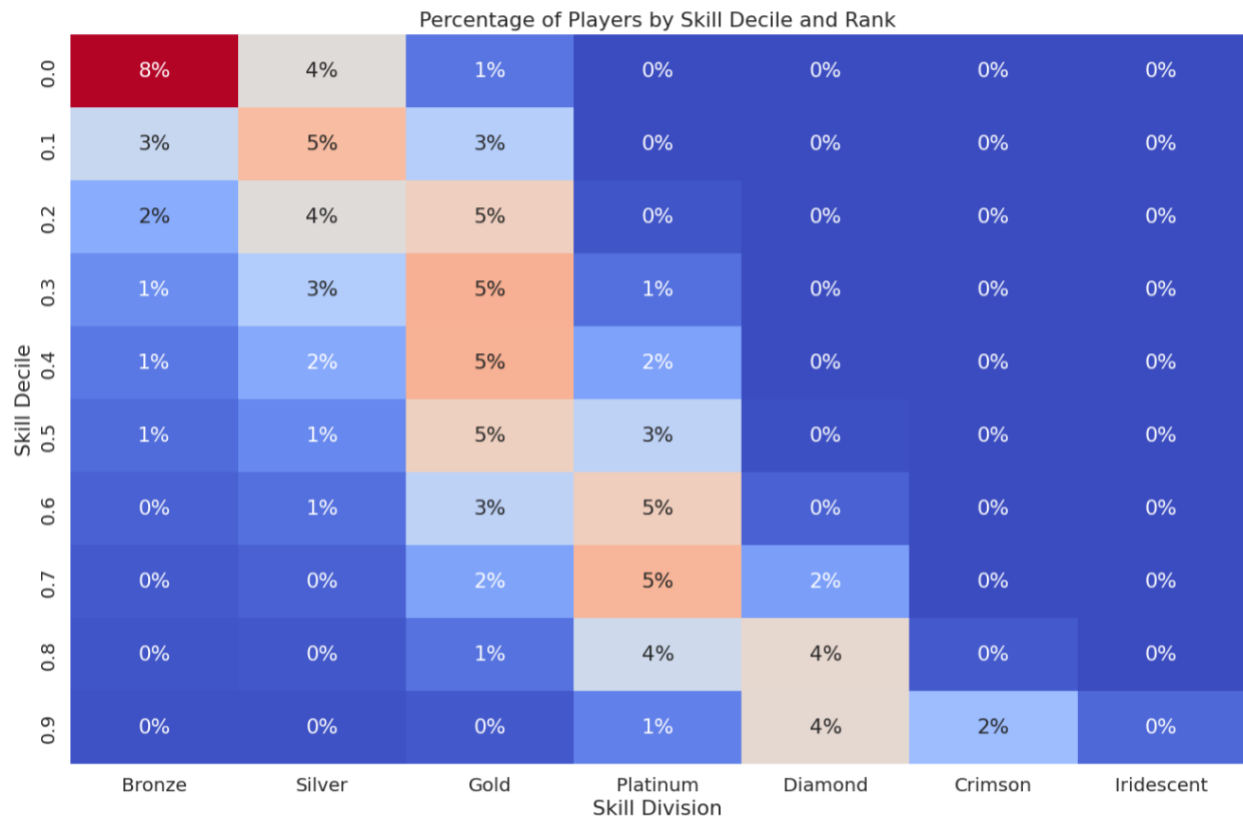


Figure 9.
The distribution of player skill percentile by Rank

In **Figure 9**, we can see that our tuning of SR clearly allows for the best players to move up the Ranks effectively. Top decile players are spread across the Platinum to Iridescent Ranks, while low skill players tend to remain in Bronze. It's important to note that this includes players who have not played many Ranked Play games, and so will not have progressed their Current SR close to their Target SR.

Including a skill component to matchmaking in addition to SR allows us to present matches to users that appear fair as players progress through their SR journey, but are also expected to be competitive and enjoyable for players of all skill levels. By tuning the SR rewards for winning and the penalties for losing, we can ensure high skill players progress quickly out of the Ranks populated by lower skilled players.

The graphs in **Figure 10** show the maximum Rank of any competitor in the lobbies that Bronze players matchmake into given their Raw Skill. What we see is that Bronze players in the bottom 25-th skill percentile usually end up in lobbies exclusively made of other Bronze players. Bronze players that end up in lobbies with Silver, Gold or Platinum competitors tend to have higher skill (that is, are themselves on the way to those higher Ranks).

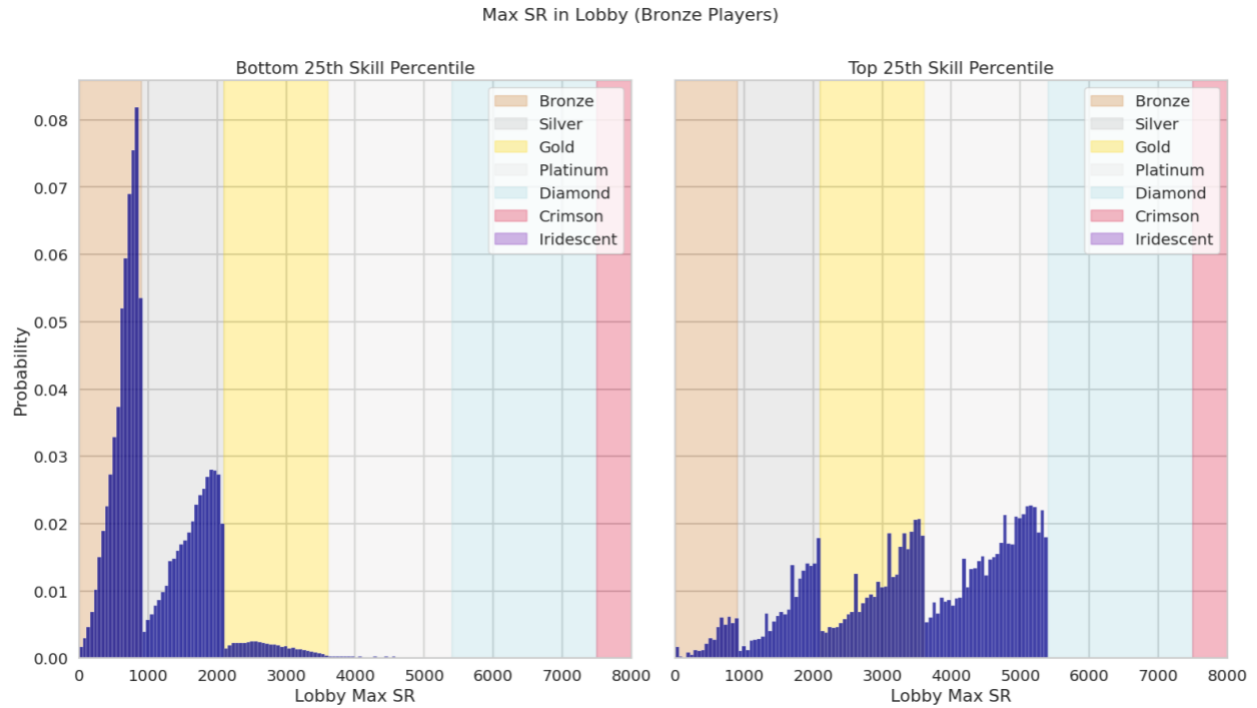


Figure 10.

Histograms comparing lobby composition for Bronze players in the top and bottom 25th Skill Percentile. In the absence of other factors, the presence of higher-Rank players in a lobby is a likely indicator that lower-Rank players are still early on in their SR progression.

This same pattern applies across the skill and SR distribution. **Figures 11** and **12** show the same breakdown for Silver and Platinum players, respectively.

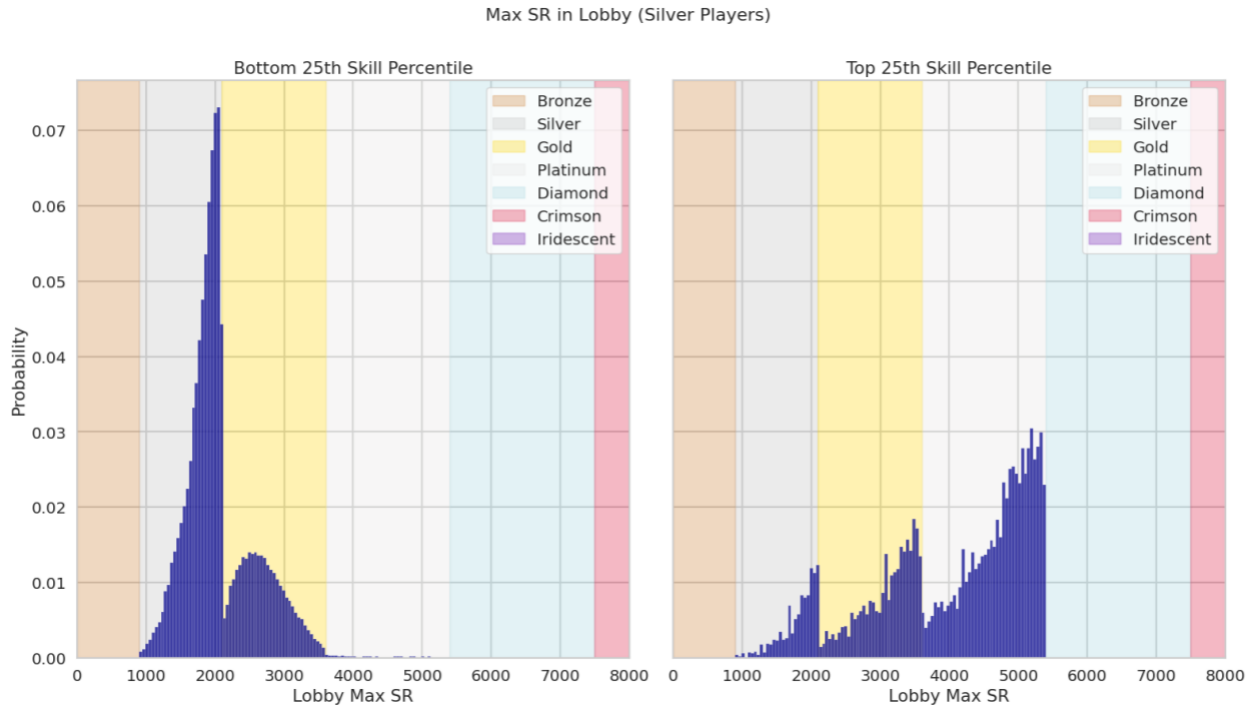


Figure 11.
Histograms comparing lobby composition for Silver players in the top and bottom 25th Skill Percentile.

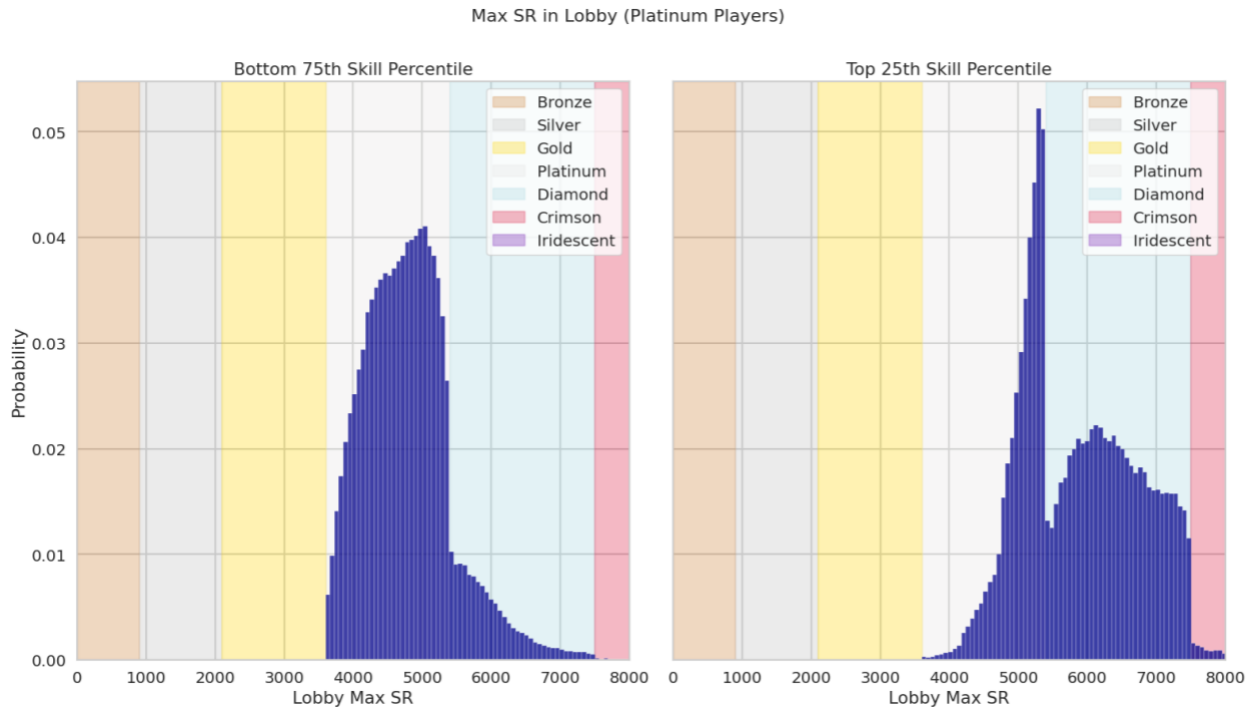


Figure 12.

Histograms comparing lobby composition for Platinum players in the top 25th Skill Percentile with the bottom 75th Skill Percentile.

This blend of matching on SR and Raw Skill allows us to provide our players with high quality matches that provide a satisfying progression of SR. This ultimately places players in a competitive environment where their SR is a clear badge of honor reflecting each player's position in the hierarchy of *Call of Duty* Ranked Play.

References

- [1] Activision Publishing, Inc. (2024, July 26). *Matchmaking Series: The Role of Skill in Matchmaking*. Activision Research.
https://www.activision.com/cdn/research/CallofDuty_Matchmaking_Series_2.pdf
- [2] Activision Publishing, Inc. (2024, April 4). *Matchmaking Series: Ping*. Activision Research.
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