Balance in Games: An investigation into utilizing dynamic difficulty adjustment in multiplayer games to maximize enjoyment.

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# Introduction

## Context

Video games are a multi-billion dollar industry ([www.grandviewresearch.com](http://www.grandviewresearch.com), 2021; www.statista.com, Nov 2022) and large corporations such as Electronic Arts (EA), Epic Games and Activision Blizzard generate large amounts of revenue through their live service competitive multiplayer games such as Call of Duty, Fortnite, Overwatch 2. Epic Games earning $820 million on PC via the Epic Games Store, with Fortnite and Rocket League being some of their most popular games (Epic Games, March 2023), and EA earning $1.6 billion through live service games alone which include FIFA, Apex Legends and the Battlefield series.

These live service competitive games match players against one another using Skill-Based Matchmaking systems (SBMM) which take in various player statistics like kill to death ratio, time spent playing the game and score per minute, and match players against those of similar statistics (Dexterto, 2023). This is to create a fairer competition and allow new players who are still learning mechanics a – somewhat – safe space to compete and learn the game, allowing them to become engaged in the game as Chen et al. (Sep 2021) state – based on research by Chen et al. (2017), and Huang et al. (2019) winning or losing has a “significant impact on engagement”. Engagement is particularly important for these live service games as it is essential to revenue generation (Chen et al. 2017), as many of these games are free to play so require in-game purchases to survive.

Skill-based matchmaking systems can also be manipulated by players who intentionally lose games and perform poorly in order to be matched with lower skilled opponents, these players are known as ‘smurf players’ or ‘smurfs’ (Julianto et al., 2021). These ‘smurfs’ then dominate their lower skilled opponents preventing them learning the game (Lapolla, 2020).

Whilst SBMM takes in player statistics before and after match, Dynamic Difficulty Adjustment (DDA) does so as the player is playing the game. DDA is used in various games such as Mario Kart, where ‘rubber banding’ is implemented to prevent the player from getting too far ahead from the AI controlled opponents.

## Goals

The focus of this paper is to analyse the strengths and weaknesses of various DDA techniques and comparing them to each other and to traditional methods of difficulty scaling in modern video games. To discover whether DDA would be effective in competitive gaming environments and to what extent each methods affects player engagement.

This verdict will be based upon prior research of DDA, user satisfaction & retention and current examples used in the industry.

## Thesis

# Literature Review

## Overview

Dynamic Difficulty Adjustment is a method of “modifying a game’s features, behaviours and scenarios” in runtime in accordance with the player’s skill level to “keep the player engrossed till the end and to provide him/her with a challenging experience”, this is different to traditional difficulty levels where it would increase in measured steps throughout the game (Zohaib, Oct 2018).

In competitive multiplayer games, the opposing players provide the adversarial challenge as both parties attempt to achieve similar goals, such as destroying the enemy base (Multiplayer Online Battle Arena games), being the last player remaining (Battle Royale games) or scoring the most goals (Sports games). Cite these.

With competitive multiplayer games like League of Legends, player enjoyment can vary greatly depending on whether the player won or not. Decelle et al.(2015) surmised that out of their 52 players 60% of players reported being unhappy after losing a match of League of Legends. This unhappiness can lead to players getting bored and quitting (also known as churn) if they fall into losing streaks (Decelle et al., 2015; Chen et al. 2021).

Dynamic Difficulty Adjustment can help alleviate the challenge for newer players by providing them with boosts such as item-based powerups or simply increasing their power statistics(?)

## Case Studies

In the 2006 beat’em up Capcom game titled “God Hand”, the player character fights hordes of enemies who’s health, damage, movement speed and other statistics can be changed depending on how the player is doing. Whilst the game does have traditional difficulty settings, it features a “difficulty level” gauge wherein the more damage the player deals without receiving any in turn the more the gauge fills, until it fills completely where the player ‘levels up’ making the enemies harder but granting the player bonus rewards for completing the stage at higher difficulty (God Hand Game Manual, 2006). This would naturally draw the player into a ”flow-state”, as described by Csíkszentmihályi (1975) a state of mind where you become totally engrossed in your task and lose you sense of time. As the difficulty of the game directly correlates to the player’s performance, as the player learns the game and gets better, the difficulty can increase.

As shown in Figure 1: The Flow channel concept proposed by Csíkszentmihályi (sourced from Zohaib 2018)

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God Hand – Manual <http://www.replacementdocs.com/download.php?view.6727>

Half Life, Valve’s first-person shooter, has a DDA known as the Hamlet System (Hunicke & Chapman, 2004) where the system has function for monitoring the game, defining adjustment actions, execute these actions and use “statistical metrics” to predict when a player is “flailing” i.e. when they can no longer accomplish their goal so the Hamlet System can intervene. This system was designed with the Flow State (Csíkszentmihályi, 1975) in mind, so the Hamlet System tries “to keep the player in the flow channel” by pushing and pulling the player into comfort and discomfort zones by increasing/decreasing damage, health of enemies, available health packs or replacing enemies completely. It can do these actions immediately (reactively) or in advance (proactively) allowing for immediate corrective actions as well as more subtle gameplay changes.

Using this technology Valve created an AI Director for the game Left 4 Dead, a zombie horde shooter, looking to create “dramatic gameplay” characterized by moments of high intensity followed by calm (Valve, 2009). to “dynamically “direct” the pacing of the game” (Booth, Nov 2018), as they had struggled to challenge the player through “traditional methods” as players were learning the spawn pattern of enemies and avoiding dangerous areas. With the AI Director, using proactive and reactive actions, being able to control what types of zombies and how many appeared in each area allowed them to achieve the goal of “dramatic gameplay” as after the players dealt with a large horde, the AI Director will “shut off” the zombies to allow player to rest and explore the environment.

However both these examples are not competitive games, on March 25th EA obtained an approved patent for DDA technology largely based on the work of Chen et al.(2017) which was an ‘Engagement Optimized Matchmaking Framework’ which, instead of focusing on solely matching players of equal skill level, used an engagement prediction model – which takes in data such as money spent in game, number of matches played recently or the player’s churn risk – to create more ‘fun’ matches for the player in order to reduce churn risk . This was met with online backlash leading to a dismissed class action lawsuit and EA releasing a public statement that they “would not use DDA technology to give player an advantage or disadvantage in online multiplayer modes in any of our games”.

This suggests that if DDA in some competitive multiplayer games could be met with disapproval, especially in free to play games with pay to win aspects, as players could believe that the DDA is used to pressure players into spending money in order to remain competitive and able to win.

However, Mario Kart uses DDA

Matchmaking

Mario Kart Rubber banding Patent – <https://patentimages.storage.googleapis.com/eb/dc/0c/8aeb201acf0f6c/US7278913B2.pdf>

## Analysing Dynamic Difficulty Adjustment Techniques

Dynamic Difficulty Adjustment can assist with closing the gap between players of different skill levels as Andrade et al.(2006) created a “Challenge Sensitive Reinforcement Learning” (CSRL) agent which uses a reinforcement algorithm (trial and error in order to learn an optimal route to maximize its reward function) which is coupled with an “action selection mechanism” which evaluates the user’s skill and adjusts its action plan accordingly (Andrade et al. 2006). They took this CSRL agent along with and tested it in a fighting game similar to the likes of “Capcom Street Fighter and Midway Mortal Kombat” – Knock’em (Andrade et al. 2004) – against 4 players, 2 at beginner level and 2 at experienced level. Comparing the CSRL agent’s results against a State Machine agent, Genetic Learning agent and a Traditional Reinforcement Learning agent, the CSRL agent had a lower variance across it’s matches with the players meaning all players performed at a similar level, therefore felt a similar challenge from the CSRL – in addition when the players gave feedback all players disagreed that the opposing agent was predictable when referring to the CSRL this displays promise in future DDA within this style of game.

Sutoyo et al.(2015) created a tower defence game where the DDA modified variables in the game as opposed to modifying the actions of an agent. The game evaluates the skill level of the player by monitoring 3 core factors: Player Lives, Remaining Enemy Health and “Passive Skills” – which are skill points the player can invest into towers to power them up. There are multiple variables which directly affect gameplay, which you can see below in Table 1 (sourced from Sutoyo et al., 2015).

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These various multipliers are adjusted by the 3 core factors, if the player takes damage and loses a life: the status multiplier will be decreased lowering the power of the enemy, the spawn multiplier will be reduced lowering how many enemies spawn and the gold multiplier will be increased which will grant the player more gold at the end of the level. If the player is doing well however with high passive skill points, they will receive more however the enemies will be more powerful. Similar to Capcom’s God Hand, 2006 however there is far more variable in terms of difficulty as there are 3 factors each affecting the difficulty in their own way, this means that players who excel at particular sections of the game are still challenged at those sections.

Baldwin et al. (2013) suggests a framework for use in DDA defining 7 components being: determination, automation, recipient, skill dependency, user action, duration and visibility.

Determination is the time/game state where the decision to use DDA is made, whether that’s during play or beforehand. This component allows flexibility for the adjustment as, in a scenario where SBMM finds a fair match however the opposing player is a “smurf” leading to an unfair game, allowing for in-game DDA could help player engagement as when players believe “there’s no chance of victory” they disengage (Decelle et al., 2015).

Automation is whether or not the DDA is performed by the game’s system or if the players must manually input difficulty adjustment. This component allows for freedom of choice, perhaps if SBMM cannot find an even match and resorts to other factors, such as ping or time spent waiting like in the Call of Duty: Warzone ([www.pcgamer.com](http://www.pcgamer.com), June 2021), players can simply agree on necessary handicaps, such as lowered health like Street Fighter 4(2008).

Recipient is whether the DDA is team-wide or player specific, this component allows for specified assistance to wherever it’s needed, whether it’s one player being outperformed by other in the match or if one whole team is suffering.

Skill dependency is whether players must still act with a degree of skill, as skill independent DDA could be health increase, speed increase and skill dependent DDA would be higher damage dealt, double jump. As the player would need to recognise and utilize the strength. This must be handled carefully as it can lead to rewarding players for losing, in Mario Kart players in lower positions are granted more powerful items, which can lead to moments where players feel like the game is punishing them for skilful play ([www.gamedeveloper.com](http://www.gamedeveloper.com), 2009).

User Action decides if the DDA instance is an active choice the player makes to use or automatically assists them. Automatic assistance can take away a player’s feeling of control which can remove them from the flow state leading to disengagement, conversely a subtle boost of assistance can elevate a player’s flow state.

Duration is the length of the DDA component, if it’s a one-time use weapon or a continual buff until the player no longer requires it.

Visibility is an important factor to consider. EA was served a lawsuit and received backlash based solely on perceived DDA. Additionally, some players may disengage if they notice certain opposing players are granted powerups, viewing the game as unfair as “someone’s score gets better without them having to actually play any better” an interviewed player claimed (Baldwin et al. 2016).

## Discussion

Most examples of DDA are used in single player or cooperative multiplayer games such as Left 4 Dead, God Hand, Crash Bandicoot, Resident Evil 4; these games all have methods to adjust the adversarial agents and regulate threats in order to keep players in the “flow state” and maximize their engagement (Andrade et al., 2006; Zohaib, Oct 2018). However, most competitive multiplayer games lack any sort of DDA beyond SBMM, this may be due to current DDA techniques used in these games alter the behaviour or number of AI-controlled opponents and technology such as the Hamlet System or Difficulty Level cannot directly apply to player-controlled opponents.

# Output Design

## Specification

## Justification

This project looks to push the technology of DDA forward into multiplayer games, as already produced techniques are somewhat limited by needing computer-controlled opponents. Popular competitive multiplayer games use SBMM as a sole means to balance matches however (reference that EOMM stuff) those matches may not be the most engaging or fun to players as described in Chen et al.() Using DDA in addition to the EOMM matchmaking system may further reduce churn risk, as there are many examples in single-player games where DDA – obvious or not – led to increased player enjoyment.

A multiplayer focused Hamlet System or Game Director can lead to intense moments in matches which would encourage players to play more and gather more players leading to increased revenue.

# References