

A Survey on Game Analytics in Massive Multiplayer Online Games

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Abstract—Massive Multiplayer Online games (MMOG or MMO games) can gather hundreds, thousands or even millions of players. They build persistent world games where social relationships are established to improve the performance of the users and their online, centralized and persistent nature facilitates the collection and analysis of user data. Since keeping players engagement is very important to the MMOG business model, the adoption of Game Analytics to better understand the player experience became widespread among game developers and researchers. This paper makes a survey of articles published over the last fourteen years that apply Game Analytics techniques on Massive Multiplayer Online Games. The objective is to outline the recent research conducted in this area: the type of MMOG that is the object of research; the most common game metrics adopted; the game telemetry used in the research. For this, 31 papers were selected from IEEE and ACM Digital Libraries and analyzed. Such selection was done by searching the keywords Massive Multiplayer Games on both libraries and Game Analytics on the ACM library. Many tendencies were found upon selecting and analyzing each paper. Such as World of Warcraft being the most researched game, while RPG was the most researched sub-genre. Other observations include that the improvement of the game was the aim of about one-third of the sample and the most common data source was the Game Log from each game.

Keywords-Game Analytics, MMOG, Massive Multiplayer Online, Video Game

I. INTRODUCTION

Video games have evolved from single screen games to vast virtual worlds where thousands of players can interact and play together or games with an emotional story where players can relate to characters. Much of this evolution come from the advances in computer, communication and display technology, which provided powerfull resources to game developers.

Amidst the plethora of video game genres, some may stand out for their popularity. For instance, Massive Multiplayer Online games became so popular that they gathered a player base of millions players for just one game, World of Warcraft [1]. This user base was reduced in 50% in the following years [2], but at the same time another large MMOG titles were launched.

It is very difficult to predict the amount of success a game can achieve. The development of a new game involves several domains, and deals with subjective aspects of the

human experience. The need for quantitative evaluation to support the decision making process in the game industry is gaining more and more attention [3]. The use of analytics to better understand game development and user experience is a consequence of that trend and is being adopted not only by the industry, but also by researchers as a more general investigation tool.

Game Analytics (GA) and Massive Multi-player Online games (MMOG) are not new themes. Analytics has been widely used to support Business Intelligence. The goal of Analytics is to detect patterns in data that can be used in decision making processes. The evolution of computing platforms and the rise of big data opened a lot of opportunities to apply Analytics in several areas. Its application to games, in the beginning, was hindered by the difficulty in obtaining a large amount of user data. The development of networked games or simply games that communicate through the Internet circumvented that limitation. On the other side, MMOG had an extraordinary development in last decade, boosted by the technological advances in computer processing and communications. Since their business model is based on player subscriptions, keeping an engaged user base is fundamental for the game success. Game Analytics, in this context, is explored to better understand the game performance and define new directions for its evolution.

This work is a survey of publications that relate both fields, aiming to identify relevant research problems, the kind of games where GA was applied and provide insights of new research directions. The articles presented here were collected by researching on ACM Digital Library [4] and IEEE Xplore Digital Library [5].

The paper sections are organized as follows. The second section discuss the motivation of this work. Section III defines the main concepts investigated. An overview of the main games studied in the papers is shown in Section IV. Section V presents the application areas of the papers. An analysis of the overall state of research made with Game Analytics in Massive Multiplayer Online games is presented in Section VI. Section VI closes the article with some final considerations.

II. MOTIVATION

MMOG is a game genre that kept a sustained data base of millions of subscribers for several years. It comprises players from several countries in a multi-million dollars business. For instance, Activision Blizzard reported 5.5 million subscribers to their Massive Multiplayer Online Role-Playing Game World of Warcraft, in 2015. At the same time, around 5 million players were playing their other Massive Multiplayer Online game, Destiny, and Final Fantasy XIV from Square Enix supposedly had over 600 thousands active players in May 2018 [6].

On the other hand, MMO is characterized by online access over the Internet where players actions are recorded in a persistent virtual world. This rich availability of user data makes MMO a good candidate to the application of Game Analytics. It provides an opportunity not only for the Industry itself but also for the academic research, since it is very difficult to obtain such a mass of data for analysis.

For those reasons, an investigation about the publication of works that apply Game Analytics to MMO is proposed. The main questions that arise are: (1) What kind of games are subject of GA and (2) What kind of data is more important in this analysis ?

III. DIMENSIONS

Researches compiled in this investigation exclusively address Game Analytics techniques applied to Massive Multiplayer Online games or the analysis and implementation of what resulted from its application. In this section, the definition of the Massive Multiplayer Online genre and Game Analytics are further explored in order to provide a better understanding of what criteria was used to gather the articles compiled in this work.

A. Massive Multiplayer Online

A Massive Multiplayer Online Game is a game that requires internet connection played with large quantity of players, with numbers varying from hundreds to thousands, or even millions, usually in the same server. Interactions among players either to cooperate, compete or simply to commute at a large scale around the world are a common factor among MMOs. Such games are mostly made for Personal Computers (PC), but there are multiples MMOs made for video game consoles and even mobile devices, such as smartphones. MMOs can have a variety of different subgenres depending on gameplay: Role Playing Game, Real Time Strategy, Simulation, Social, First-Person Shooter and many others. An exact definition of MMOG was not found in the literature. For the purpose of clarifying what will be considered MMOG in this paper, the following criteria must be met:

- Must contain some sort of interaction between players
- Must enable a large number of players inside the same game instance

To exclude games not commonly associated with the MMO genre, a large number of players must consist of more than a hundred. But that is not to say that games with fewer than a hundred players can't be considered a MMO game. The number was chosen because of the Battle Royale genre, that features a large number of players, usually a hundred, in a single instance and such games are not considered MMOG for the general public.

B. Game Analytics

Analytics is the process of discovery, interpretation and communication of relevant patterns in data. When such concepts are applied in the video game industry, it defines Game Analytics. Game Analytics is the employment of data analysis techniques to assist game development [3]. Much of its analysis come from data obtained from game-user interactions. Results from the analysis may be used in all phases of game development: Conception, Design, Programming, Testing and Releasing [7].

Game Analytics may be used in a variety of ways. Listed below are some ways games can be improved by the application of such techniques.

- Balancing games with player versus player modes, by analyzing those competitions and trying to identify if there exists aspects that give unfair advantages.
- Discovering which game area can be improved upon to increase player base.
- Predicting player behavior to increased Artificial Intelligence effectiveness.
- Predicting Income Revenue when games have a pay to play plan.
- Better understanding of player's motivation for playing

It may also be applied to understand human behavior as a whole, not only inside the digital world.

IV. GAMES

This section presents the games which are subject of the 31 compiled articles in this survey. Some games are briefly described, while others are more detailed, according to their relevance in this survey.

A. World of Warcraft

Since Activision Blizzard stopped reporting their numbers of subscribers [2], there is no definitive way to tell how many active players are engaged with World of Warcraft (WoW). Even though, by tracking the numbers of subscribers to one of the most famous social news Web sites, Reddit, one can compare each MMO community to get a rough estimate to their popularity in relation to other games. By using this metric, World of Warcraft remains as the most popular MMO game, with more than 700 hundred subscribers [8].

Besides its notoriety, WoW made its large user database public available. For such reasons, WoW is the most Massive

Multiplayer Online game researched upon. Eight articles presented in this work made their research either using data from World of Warcraft, or applied their thesis to the game to gather results.

Launched in 2004, World of Warcraft belong to the sub genre Massive Multiplayer Online Role Playing Game (MMORPG), where players embark on a journey across the fantasy medieval land of Azeroth. Players are able to customize their avatar and choose one side between two factions at war to ally themselves with. Six expansions have been released, with a seventh on the way [9]. The game's monetization plan constitute of a pay-to-play ideology, based on a subscription model, where players pay subscription monthly to play for a month.

B. *EverQuest 2 and Runescape*

Recognized by Guinness World Records as the most popular free MMORPG, Runescape, published by Jagex, has also the second biggest community in Reddit, second only to World of Warcraft [8]. It's popularity is one of the reasons that it appeared on more than one research [10], [11]. Runescape is set in a medieval fantasy world, Gielinor, where players are able to customize their character, interact with others and define their own objectives.

On the other side of the spectrum of popularity stands Everquest 2, an MMORPG which is the second most researched MMOG inside the sample collected for this research [12], [13], [14] despite being ranked in 52th place in Reddit MMOG communities [8]. Everquest 2 was released in 2004 by Sony Online Entertainment featuring a medieval fantasy 3D world where players can create their avatar, partake on adventures and interact with other players. It started as buy to play game, but went to another monetization plan of free to play, with options to pay for more content.

C. *CMX*

In the articles written by Christos Malliarakis et al. [15], [16], the MMO game explored is CMX. It is an educational MMORPG which aims to teach students the basic elements of computer programming, such as variables and if-statements. It also features different roles, like students, teachers, administrators and other educational agents. [17]

The game pits two teams against each other, hackers and crackers. While hackers need to protect a toxic waste factory that employed them, crackers are trying to invade it. Included in the game are special characters, Senseis, whose goal in the storyline is to teach players how to engage in computer programming along with providing hints. [17]

D. *Mammoth (framework)*

Mammoth, cited in the paper authored by Hammad Khan et al. [18], presents itself as massive multiplayer game research framework, whose goal is to provide an experimentation environment designed for the academic purpose.

Mammoth's world consists of a fixed number of characters viewed from a 3D perspective. Players are able to interact with other players by private messaging or engaging in multiplayer conversations. They are also able to execute basic functions such as moving around, examining, picking and dropping in-game items.

Developers are allowed to run different distribution configurations of the game, such as classic client-server, hybrid or Peer-2-Peer. A remote monitoring of nodes present in a Mammoth game and a logging of game events are also possible inside the framework. Mammoth allows the definition of non-players' behavior, controlled by artificial intelligence algorithms or statechart-based models. [19]

E. *Destiny*

Unlike every other paper discussed, one research [20] focused on a console exclusive game, Destiny. While not being classified as a MMO, it incorporates many aspects of the genre. As discussed in Section IV, this article was chosen to give a broader range of games as Destiny is a First Person Shooter game and reaches a different base of players, those who only play video games on consoles.

Destiny was first launched for PlayStation 3, PlayStation 4, Xbox 360 and Xbox One in 2014 as a Shared World First Person Shooter with RPG and MMOG features, made by Bungie. It featured a Science Fiction theme, where humanity is fighting to protect the last city on Earth against the darkness. Four expansions were released before the sequence in 2017. Destiny's monetization plan is buy to play, where players pay once for the base game, and play for as long as they want, with additional content costing extra. Destiny's MMOG aspects includes a need for constant online connection, social interactions, multiplayer and a big amount of players in each session.

F. *Travian and Rokkatan*

In the mist of many MMORPGs, it is not common to find other subgenre being discussed. To take advantage of this lack of discussion, a couple of papers [21], [22] offer researches on MMO Real Time Strategy games.

Rokkatan [21] was created to serve as a game design demonstrator for a massively multiplayer real-time strategy game as well as to serve as technical evaluator for replication concepts and proxy-server topology, demonstrating the scalability of these approaches. Because of these design goals, it functions as a case study for design and implementation of an MMO RTS. Rokkatan's game takes place in a game map, described as an editable text file, where teams compete with each other. Players have to engage in different goals with group coordination to occupy and protect already occupied flags.

Travian is a MMO Browser-based RTS set in classical antiquity, developed by Travian Games [22]. New players are given the leadership role in a small, underdeveloped

village with resource fields around it. Players may interact with other players in order to join alliances or economic co-operations. They may also expand their territory by starting new villages or conquering other player's villages. Trivian is also a free to play game.

Besides the games presented above, the following games were also investigated by at least one research:

- BrowserQuest [23]: Medieval Fantasy MMO Browser Game.
- Second Life [24]: Real Life Simulation MMO.
- Zhenttu [25]: Chinese Mythology MMORPG.
- Ragnarok [26]: Medieval Fantasy MMORPG.
- Mabinogi [27]: Welsh Mythology MMORPG.
- AION [28]: Fantasy MMORPG.
- Tera [29]: Fantasy MMORPG with a console port.
- Eve [30]: MMORPG.
- Lineage [31]: Fantasy MMORPG

V. APPLICATION AREAS

Presented in this section are brief summaries of articles gathered, which were divided by common themes among them. Table I list all articles with their year of publication, purpose category, from where the data analyzed comes from and the Digital Library it belongs to. In the Subsection *Simulate Reality*, papers, which make the effort to simulate reality or to investigate if something from a MMOG does simulate reality, are briefed. Papers that do research on social interactions of MMOGs belong to *Social* Subsection. Papers that focus to improving the game are described in the Subsection *Improve Game*. Some papers explored the better understanding of MMOG players and MMO games, those belong to the Subsection *Understand Player* and Subsection *Understand Game*, respectively. Finally, the usage of MMO for education purpose are explored in Subsection *Improve Education*. Some papers may belong to more than one category.

A. Simulate Reality

Inside MMO games, players are able to behave freely within each game's rules. In this kind of environment, it is possible research human behavior, as each player tends to think what they would do if they were in their avatar's place. To make most of this test environment and the potential sample size, researchers aimed to study how an MMO game could serve as a epidemiological simulation tool [23]. By comparing their results to other simulation techniques they obtained similar results, demonstrating MMO's potential as modeling tools for disease dissemination. More than just player behavior, player's community structure can be compared to various real-world networks. Those notions are explored in a paper, where their authors try to cluster player's community [37].

B. Social

One important element for all MMOG is the social relationships it stimulates by grouping together a massive number of player and letting they play, interact e compete with each other. The social aspect of MMOGs is explored in the following researches. Some papers [26], [37] investigate clustering methods for player's communities. One study [13] describes an approach to track groups, as they interact with larger networks of groups. Another paper [36] focuses on social interactions of the individual player, stating that one player may show different social relationship with others in different activities. Finally, the exploration of how MMOG experts behave socially inside the game was also researched upon [14].

C. Understand Game

In order to better understand the MMOG phenomenon and their gameplay requirements, researchers [32] interviewed 12 practitioners from three leading MMOGs-producing companies and reviewed their gameplay requirements documents. Mentioned before, a study was conducted to try to track group of players and how those groups interacts in networks of larger groups inside the investigated MMO game [13]. One paper [39] investigates the Quality of Service of MMO games and proposes some sort of metric to evaluate it. In a effort to observe the digital market condition, Sheng-Yi Hsu et al. [41] describe an indicator product to analyze purchase decisions made inside a MMO. Inside a MMO, there exists countless opportunities to explore and learn about the virtual world. To better understand how the learning process is done was focus of one investigation [31].

D. Improve Education

A paper [31] investigated how learning was done inside the virtual world of a MMO. One article expanded upon that idea and explored what Massive Open Online Courses could learn from MMO games in regards of motivation, grouping, structure, and assessment. Despite not being in the Game Analytics field, one research [35] is presented here nonetheless to show where it could be applied in future works. Another paper explored the integration of immersive elements from MMO games into mobile learning, creating a prototype and testing it with volunteers [34]. Finally, both works by Christos Malliarakis et al. [16], [15], aim to teach computer programming with a MMORPG by integrating Learning Analytics [15] and analyzing the effects [16].

E. Understand Player

The second most researched subject is the effort to understand the player, not only their interactions, but also their behaviors and tendencies. The authors from one study [14] investigated the behaviors of expert players and their interactions. Similarly, one paper [12] explored the phenomenon of mentoring, where more experienced players would guide or

Table I. Articles Researched

Research	Year	MMO Game	Data Origin	Purpose	Library
[32]	2014	-	Survey	Understand Game	IEEE
[33]	2011	WoW	Game Log: Action Sequences	Improve Game	IEEE
[14]	2009	EverQuest 2	Game Log: Chat Log	Understand Player / Social	IEEE
[34]	2008	-	Survey	Improve Education	IEEE
[35]	2014	-	-	Improve Education	IEEE
[18]	2015	Mammoth(framework)	Performance: Delay, Scalability, Load Balance	Improve Game	IEEE
[16]	2016	CMX	Survey / Game Log (Player's Performance)	Improve Education	IEEE
[23]	2015	BrowserQuest	Game Log: Rate of Infection Log	Simulate Reality	IEEE
[15]	2014	CMX	Game Log: Activity metrics, Frequency of errors, time,collaboration metrics, Player's performance	Improve Education	IEEE
[21]	2012	Travian	Game Log: Activities / Attributes / Chat Log	Understand Player	IEEE
[24]	2012	Second Life	Game Log: Chat Log	Understand Player	IEEE
[13]	2011	EverQuest 2	Game Log: Level	Understand Game / Social	IEEE
[12]	2010	EverQuest 2	Game Log: Level / Time / Activity	Understand Player	IEEE
[36]	2009	WoW	Game Log: Activities, Level, Time, Guild Members	Improve Game / Social	IEEE
[25]	2009	WoW e Zhengtu	Game Log: Friends, Time, Level, Activity	Understand Player	IEEE
[37]	2009	WoW	Game Log: Class / Score / Guild Degree	Understand Player / Social / Simulate Reality	IEEE
[26]	2008	Ragnarok	Survey: Age, Gender, State, Occupation, Character level, Class, Time, Game events frequency, Locale of play, PVP mode frequency, Motivational factor.	Understand Player / Social	IEEE
[10]	2011	Runescape	Game Rules: game trading safety features	Improve Game	IEEE
[38]	2007	WoW	Survey: Time, Social / Participant observation and Content analysis	Understand Player	IEEE
[27]	2007	Mabinogi	Survey: Motivation, Perceived Fun, Perceived Transaction Cost, Intention of Trade, Intention to play	Understand Player	IEEE
[28]	2017	AION	Game Log: Virtual economy transactions	Improve Game	IEEE
[30]	2014	Eve	Game Log: User movements	Improve Game	IEEE
[29]	2012	Tera	Game Log: Quests Completed, Friends, Plant and Miner, Monster killed, loot total items, Deaths, Auction and Level	Understand Player	IEEE
[39]	2008	WoW	Survey: Delay, Jitter, Data Rate	Understand Player / Improve Game	IEEE
[40]	2012	-	Game Log (Simulation): Class, Type, Item Value, Item Possession	Improve Game	IEEE
[7]	2017	WoW	Game Log: Play Density / Level	Understand Player	IEEE
[22]	2005	Rokkatan	Performance: Scalability, Prediction Quality	Improve Game	ACM
[31]	2004	Lineage	Survey, Observation, Activity	Understand Game / Improve Education	ACM
[11]	2010	Runescape	Performance: Time to identify Players followed	Improve Game	ACM
[41]	2017	WoW	Game Log: Virtual economy transactions	Understand Game / Improve Game	ACM
[20]	2018	Destiny	Survey	Improve Game	ACM

help less experienced players in MMOs. Besides using social metrics, the main purpose of one research [21] was to predict player's performance or potential to win a game. Regarding players' feel for the game, student discourse recorded during a marketing case study exercise in a MMOG was analyzed by the authors Sabine Emad et al. [24]. They found that participants showed signs of being fully immersed in the activity.

With the aim to classify players of MMOs, one study [25] used degree distribution of the relationship network, and applied the methods to two types of MMOG with different

payment patterns. By combining participant observation and content analysis approaches, an examination of what degree of tribalism can be observed within players [38]. As discussed before, researchers [26], [37], [29] explore ways to cluster players together. One such also compares data from a MMOG with that of a multi-player strategy war game [29].

One paper [7] aimed to predict if a player will pay a monthly subscription to continue to play a MMO, by clustering players and analyzing their attributes. Finally, one study [27] investigated what happens to user's motivations when affected by the implementation of Trading Systems of

Digital Content Accessories inside MMOGs.

F. Improve Game

The following articles investigate what can be done to improve upon a MMO game, with some even proposing new ideas and methods for such. Some researchers [33] aim to improve the game's balance by proposing a method to identify bots, while another study [28], with the same objectives, presents a way to identify groups of gold farming.

The challenge of monitoring the state of a distributed virtual world is tackled by one specific paper [18], whose authors test their middleware in a framework that simulates a MMO game. As mentioned in a previous subsection, one study [39] proposed a Quality of Service metric, done in order to improve game evaluation. Another article [41] investigates market tendencies inside a MMOG and ways to predict it, such results can improve the quality of future item releases.

Engagement is crucial for a game's success, so the authors in [10] explored the balance between safety and danger and its effect on engagement. But when a lot of players suddenly become engaged in a game, it can generate problems. To address such concerns, [30] was done in order to predict unexpected player influx. Another article that investigates the prediction of information is [40], which explores the impact of loot distribution systems on player base.

One conclusion of a previous mentioned research [36], is that existing guild organization cannot satisfy the requirements of multi-activities in MMOG. This conclusion shows an area which can be greatly improved in the future. Another area of improvement suggested by researchers [11] is the continuous analytics made by MMO games. Their solution was the use of cloud programming to assist it. In contrast to other research, [20] which explores a console game instead of one that's played on a Personal Computer, and proposes new ways to implement player versus player activities. Their authors also conducted an interview with players to assert the proposition. Finally, the last article presented here aims to scale a Real-Time Strategy Game to a MMOG [22], describing what should and can be done.

VI. ANALYSIS

The articles analysed in this research were chosen from two different digital libraries. The first database was IEEE-Explore [5]. Using the keywords "Massive Multiplayer Online", it resulted in 80 papers, from which 25 were selected based on the criteria that it had integrate Game Analytics somehow. If the keywords "Game Analytics" was applied in conjunction to "Massive Multiplayer Online", it would lead to only 2 papers being shown as result, much less than what it should have been. This may be due to authors applying Game Analytics but not specifying it as a keyword when submitting their work. One additional research [7] was also

included, even though it did not appear as a result, as it fits the criteria.

Upon searching the keywords "Massive Multiplayer Online" and utilizing the advanced search tool to match all words inside the ACM Digital Library [4], it leads to 2,148 results. To decrease the number of possible relevant papers, the keywords "Game Analytics" were used in conjunction to the last search. Resulting in 43 papers being shown. From that result, 5 papers were selected to be part of this compilation, as most of them did not actually research MMO games or did not applied Game Analytics in their work.

Papers compiled here were not chosen based on their publication type, whether they were published in conference's proceedings or journal. Of thirty researches, only two belonged to journal publications [16], [28], and one was featured in a journal one year later than its proceedings publication [22] and, due to their similarities, the journal publication was not considered. Searching in ACM displayed thirty eight proceedings and six journals, as in IEEE, seventy three belonged to conferences and seven to journals. Comparing their results, IEEE displayed 9% of journal publications, similar to the percentage found in this work, roughly 7%, but a bit different from ACM's result, 14%. Such numbers may be attributed to the more demanding nature of journals, or to the competition found in non-specific journals, as Game Analytics or Massive Multiplayer Online do not have a dedicated journal, at least none was found in both sites.

Figure 1 displays article distribution per year, from which, it can be inferred that interest in this field of study is mildly present. Ever since 2006, there were only two years when less than two papers were published in this compilation, 2018 is not counted as the year has not yet ended.

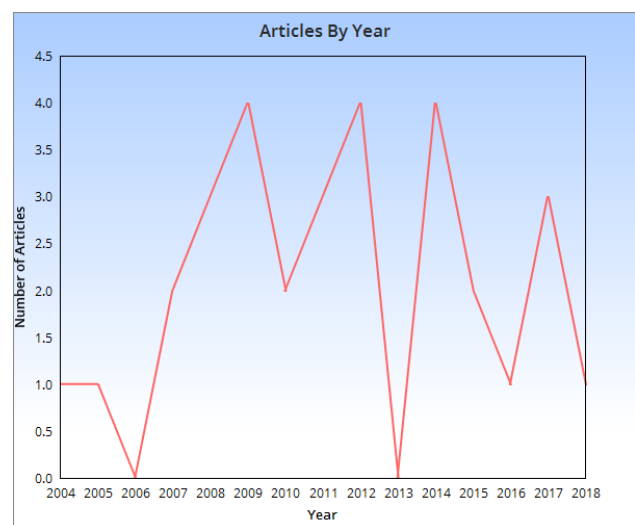


Figure 1. Articles By Year

When analyzing to what purpose were those researches made, one can group them based on common themes. As discussed in Section IV, the themes chosen for this work are: Simulation of Reality by using MMOs, understanding of the MMOG phenomenon and its games, improving education by using MMOs, exploring the social aspect of such genre, understanding MMOG players and finally ways to improve the game and genre. Figure 2 shows article distribution per purpose, it is important to keep in mind that some articles may have more than one purpose. By looking at the figure it is easy to see that most researchers focus on improving the game or trying to understand those who play it.

Improving a game it is not only interesting to game developers and companies as it is important to those who play it, which can be the case for many researchers. Considering the amount of people who can enjoy the improvement of a game, independent of genre, it is not surprising that it is the purpose most common among papers selected here. The runner up, *Understand the Player*, may be attributed to the massive amount of available samples for any research. The player base of MMOs tend to be considerably bigger than the amount of answers obtained by a conventional survey. Thus, when researching games with humans as the object of study, MMOs provide a large database for analysis.

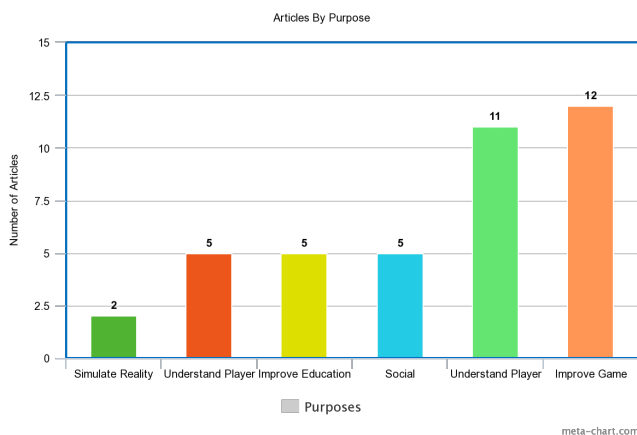


Figure 2. Articles By Research Purpose

There is a variety of Game Metrics that can be used in the analytic process. Deciding what metric to use depends on what answers are being looked for. Data can be generated from a multitude of sources and, in the context of this research, the following data origin were found: *Game Log*, provided by databases made public by the company with anonymous data or recorded by researchers when performing experiments; *Survey data*, provided by players or developers answering a questionnaire or personal inquiry; *Performance data*, derived from hardware and software performances; and *Game Rules Data*, where researchers study rules which constitute a game. Article distribution per Data Origin can be seen in Figure 3, clearly showing a majority of articles

using Game Log data, instead of other sources.

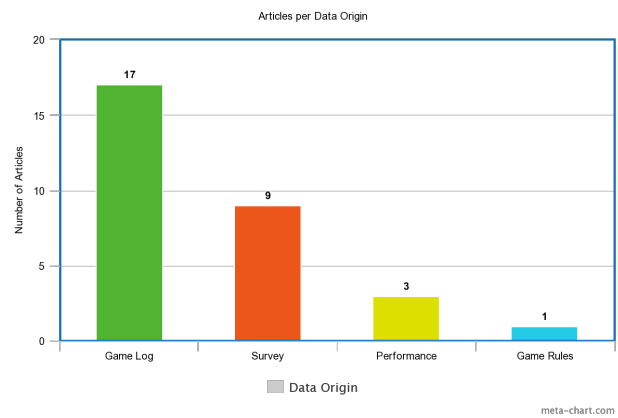


Figure 3. Articles By Data Origin

To conduct analysis on data collected, researchers have to choose certain metrics. Despite this decision varying from paper to paper, some have chosen the same metrics while others have not. Two studies which analyzed Performance Data ([22], [18]) used Scalability as Performance Metric while other researchers [11] used time to identify player's performance. Prediction Quality was used by Jens Müller et al. [22] and Delay and Load Balance were considered by Hammad Khan et al. [18].

Among those researches that explored Survey Data, most tend to focus on player's perception of the game and himself. Questions are mostly guided towards what each author's specific research goal is and their answers are quantified for analysis. Since Game Log Data is the data type most used, it naturally has many different metrics applied to it. Figure 4 shows the five most used metrics and how many papers apply them, displaying Player's Level and Actions and Activities as most used in researches. A player's level is a quantified value of the player dedication to the game, as it increases the more the user plays. When combined with other indicators it can generate new data, for example, if the player has a high level but played for fewer hours than the average player on the same level, it could be an indication that s/he is more skilled than the average player.

Some publications do not address one specific MMO game. They may study generic aspects of MMOG development or its application in some area, but most of them select one game for analysis, as can be observed in Table I. Figure 5 displays how many articles refer to the same games. One major factor in the dominance of World of Warcraft is likely to its popularity and large player base, but Everquest 2 is the second most researched game and its popularity is surpassed by other MMO, such as Runescape [42]. Another factor that may play a big role in choosing which game to analyse is data availability. It does not matter if a game is more popular than another if data is not available for the former.

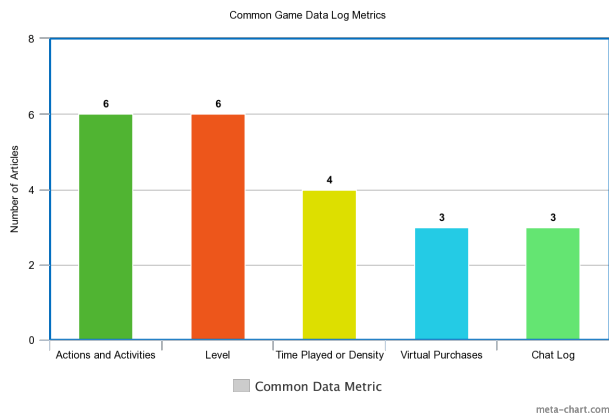


Figure 4. Articles by Data Analytics Metric

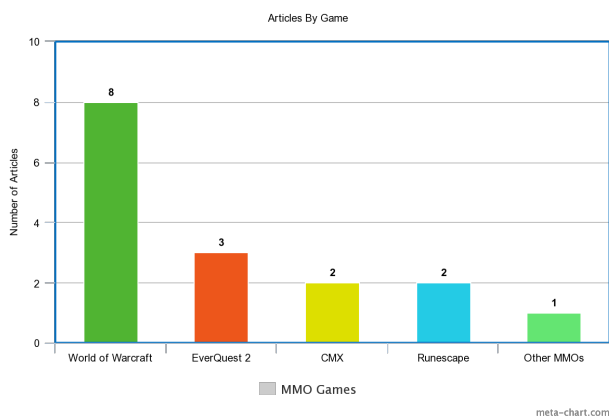


Figure 5. Articles By Game

The vast majority of the publications about GA with MMO games deals with RPG subgenre, as can be seen in Table II: eleven out of sixteen games are RPG. Further research is needed to find out why there are so many MMORPGs. One interesting note is that out of sixteen games, only one is exclusive to consoles, all other games are playable on a Personal Computer, with only having a console port.

VII. CONCLUSION

The survey presented here selected 31 papers for investigation. Many others could be certainly included, but the size of the sample should be representative of the research conducted in the area over the last fourteen years.

In terms of Application Area, about one-third of the publications focused on *Improvement of the Game*, which seems a fair goal since it addresses the aspirations of stakeholders, developers and users. The most common source of data was the *Game Log*, adopted in seventeen papers. The most used Game Metrics were *Actions and Activities* and the *Level* of the player, in twelve publications. By far the most investigated game was World of Warcraft, which is

Table II. Game's Subgenre

Game	Subgenre
World of Warcraft	RPG
EverQuest 2	RPG
CMX	Educational RPG
Runescape	RPG
AION	RPG
BrowserQuest	Browser RPG
Destiny	First Person Shooter
Eve	RPG
Lineage	RPG
Mabinogi	RPG
Mammoth	Framework
Ragnarok	RPG
Rokkatan	Real Time Strategy
Second Life	Simulation
Tera	RPG
Travian	Strategy

featured in eight publications, probably because it provides a large data base of public users and also because it is the most popular MMO. The Role-playing Game was the most common game subgenre among those surveyed in this work, present in eleven of the sixteen games.

It may be noted that while Game Analytics was been driven by the Gaming Industry for monetization purposes, it has a much larger application. Understand the player and the game can be an important asset in gamification, with social and educational impacts. Educational MMORPGs are a step in that direction.

The main application areas of Game Analytics in MMOG were *Improvement of the Game* and *Understanding the Player*. It seems that there is still a lot of research to be done in those areas. For instance, the use of biosensors introduces a new dimension for understanding the player. Emotions and physiological parameters can be correlated with the game experience in order to produce a broader source of data to be analyzed. Also, the degree of adaptation of the game to the player can reach deeper levels, taking into account user emotions based on run time analytics.

Finally, MMOs are very suitable to Game Analytics due to its online and persistent properties. However, this field of research is far from being mature. Its inter and multidisciplinary nature, which includes aspects related to the human being, opens a wide spectrum of research opportunities.

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