Large-Scale Conflicts in Massively Multiplayer Online Games

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Abstract. Complex systems are of interest to the scientific community due to their ubiquity and diversity in daily life. Popularity notwithstanding, the analysis of complex systems remains a difficult task, due to the problems in capturing high-volume data. Massively Multiplayer Online Games (MMOGs) have recently emerged as a tractable way to analyze complex system interactions, because these virtual environments are able to capture a great amount of data and at high-fidelity, often tracking the actions of many individuals at a time resolution of seconds. MMOGs have been used to study phenomena such as social networks and financial systems; our focus is to identify behaviors related to Large-Scale Conflict (LSC). In this paper, we review how one particular MMOG allows large-scale complex behavior to emerge and we draw parallels between virtual-world LSCs and real-world LSCs. The LSC-related behavior that we are interested in identifying deals with the conditions that lead a participant in the virtual environment (a game player) to engage and actively participate in a LSC, with the goal of informing an agent-based model that predicts when any one player is likely to engage in conflict. We identify virtual world behavioral analogues to real-world behavior of interest (i.e. insurgent behavior), and link the virtual behavior to a (previously derived) theoretical framework that analyzes the determinants of participation in the civil war of Sierra Leone. This framework identifies three general theories that collectively predict participation in civil war (a type of LSC); we operationalize one of the theories (Theory of Social Sanctions), and look at how insurgent behavior can occur as a function of community networks, which are assumed to impose social sanctions for non-participation in an LSC.

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1 Introduction

Understanding and anticipating changes in complex social systems, such as those relating to economies, financial institutions, and conflict is a problem of importance for national security. The complexity of these systems, such as the large number of factors and the human element, makes gathering data and running controlled experiments difficult. Promising methods such as modeling and simulation have made headway, however they are also subject to additional complexity issues and may face limited applicability.

Recently, a new source of data has emerged that can help in understanding complex social systems – data from Massively Multiplayer Online Games [1]. MMOGs afford and promote complex social interactions amongst hundreds to thousands of players in online fictional worlds, attracting players from a wide variety of backgrounds, age groups, and genders. MMOGs serve as a tractable way of analyzing complex social interactions, due to two important features. Firstly, they serve as environments with a high-degree of expressivity, i.e., they allow the participants (also known as "players") to pursue a wide variety of complex social actions, in broad categories such as peer-to-peer and group communication, economic trading, and congregating with other players. Secondly, due to the virtual nature of the environments, MMOG's are able to capture a great amount of data and at high-fidelity, often simultaneously tracking the actions of all individuals in near-real time. MMOG's have been used to study phenomena such as education [2,3], social networks [4,5], and financial systems [6,7]; our focus is to identify behaviors related to Large-Scale Conflict (LSC).

In this paper, we review how one particular MMOG allows large-scale complex behavior to emerge and we draw parallels between virtual-world LSC's and real-world LSC's. Our data set covers the actions of players in this MMOG for a period greater than one year, which we analyzed to identify the following LSC behavior of interest: under what conditions does a game player participate in a LSC? We analyzed this information with the goal of informing an agent-based model that predicts when any one person is likely to engage in conflict. Our methodology involves identifying virtual world behavioral analogues to real-world behavior of interest (i.e. insurgent behavior), and analyzing the virtual behavior with real-world predictive models of participation in LSC. To that effect, we employ a (previously derived) theoretical framework that analyzes the determinants of participation in the civil war of Sierra Leone. This framework identifies three general theories that collectively predict participation in civil war (a type of LSC); we operationalize one of the theories (the *Theory of Social Sanctions*), and look at how virtual insurgent behavior can occur as a function of community networks, which are assumed to impose social sanctions for non-participation in a LSC. These communities are defined by communication patterns, as well as virtual group co-memberships. Generally, our hypotheses predict that the more members of a players community are involved in a LSC, the more likely the player will engage and be active in the LSC. Our results apply to a virtual setting, and we discuss how they might generalize to real-world setting, which is of primary concern.

2 Details of Our MMOG Environment

Our data was obtained from a Massively Multiplayer Online Game, which is confidential in nature. To protect the identity of the parties involved in the game's creation and management, we have anonymized some of the terminologies in the game's description. None of the game's interactions or mechanics have been changed.

2.1 Overview

Game X is an open-ended free-to-play Massively Multiplayer Online Game. Players can pursue a variety of different roles and interact with other players (real and artificial) in the virtual world. In Game X, every player commands one vehicle, with a set cargo capacity as well as defensive and offensive capabilities. Players use this vehicle to explore an open, persistent game world.

Game X is unique in that the game does not impose an explicit goal structure and a player cannot win the game. Instead, the game encourages players to make up their own goals, role-play and to acquire wealth, fame, and power, in an environment driven by several societal factors, such as friendship, cooperation, competition, and conflict.

Players have a limited number of "turns" per day. Nearly all actions cost some number of turns to execute. Turns are replenished per hour. The basic categories of actions players can undertake are: economic, social, and combat.

2.2 Economic Activities

Players can mine goods integral to improving their economic performance in game. To obtain other goods, they may engage in trade, which can be a form of barter or via the use of *marks* an in-game currency. With enough game experience and the proper amount of marks, a player can construct a factory outlet, which can manufacture sellable goods. In addition, a player can eventually earn enough resources to build and maintain a market center, which can facilitate bartering and selling with passerby players.

Players can also be strategic about the location of their factories and market centers, by exploring critical city areas that are ripe for developing profitable trade routes. By the same token, players must take care to avoid establishing business in areas that are targeted by pirates; other players can plunder factory outlets, market centers, as well as vehicles.

In addition to piracy, other "illegal" (in terms of society, not in terms of what is permissible in game) options for economic activity also exist: a player may elect to bootleg illegal goods. If caught, a player can be subject to social sanctions and be barred from bartering and (if it was a repeat offense) from being able to engage socially with other players. Other sanctions include: not being able to repair your vehicle, and not being able to approach/visit city areas.

2.3 Social Activities

Players in Game X can also socialize and associate with other players through a number of different ways. In fact, to be successful in the game world, it behooves players to forge social partnerships.

To socialize, players can post on public forums, send personal messages to other players as well as broadcast messages top specific groups of players. An important feature of communication methods in Game X is that they do not cost players any amount of available turns; communication is "free of charge."

To associate, players can join one of three pre-defined nations; players can only affiliate with one nation at a time and doing so yields certain benefits, such as the possibility to gain access to nation-specific technology. Players may also elect to not join a nation, which allows them to be exempt from nation-centric wars. In addition, players can create or join a guild, which are entities designed to combine groups of players and allow them to operate for (possibly) common aims. Guild membership is independent of nation membership. For both nation and guild memberships, if a player accumulates sufficient in-game experience, he or she can be promoted to a senior level, which commands a higher influence in the respective nation or guild. In fact, senior level members of nations command considerable political power in the decision to go to war (see Section 2.5).

Finally, players can designate other players as friends or hostiles, which facilitates or hinders communication and other game activities with those players. Friend/hostile tables are completely private, meaning that no one except the labeling and labeled players has information about ties between them (i.e. it is not possible to see second degree neighbors, such as friends of friends).

2.4 Combat Activities

Players can engage in combat with other players (real and artificial), as well as with factory outlets and market centers. Players can outfit their vehicles with a variety of different weapons and defensive armors that (alongside a player's skill) can be used to give certain advantages in battle.

Players have an array of skills they can improve based upon their successful in game battles. Higher skill values increase the probability of successful combat in the future.

2.5 Potential for Large Scale Conflict

Large Scale Conflicts (i.e. wars) are socially centric and very related to combat activities. Wars are only possible between the three pre-defined nations. Each nation can have one of the following diplomatic relations to all others: Benign, Neutral, Strained, or Hostile.

The senior members of a nation constitute the nation's governing body. Every day, each nation's governing body convenes and each of the senior members chooses a disposition with regards to diplomatic relations with the other nations. Non-senior members cannot vote, but can exert influence by lobbying senior members to vote a certain way. If enough members of a governing body select hostile diplomatic relations against another nation, a war is declared between the respective nations.

When a war has broken out, additional combat actions are available for the warring nations. In particular, war quests are available, which provide medals of valor to the players that wish to undertake and complete the quests. Any attack against the opposing nation (be it in the form of a war quest or not) results in accumulating a set number of war points. When the war ends, these war points determine the "winner" of the large-scale conflict. A war situation will (via the game's design) gravitate towards a state of peace. Each of the respective governing bodies must maintain a majority vote to continue the war effort. Over time, the amount of votes required to continue is increased by the game itself. Eventually, no amount of votes will suffice and the nations return to a state of peace.

2.6 A Player's Death

A player cannot permanently die in Game X. If an enemy destroys a player's vehicle, then the player loses a fixed amount of skill points, as well as all the cargo on his or her vehicle and in addition loses some available actions for the play session.

3 Validity of Our Work

Our primary interest is to identify under what conditions is a player likely to engage in conflict. As previously mentioned, the idea is to use our MMOG environment as a testbed for theories that predict participation in large-scale conflict; we posit that our virtual environment is a reasonable proxy for behavior that we could expect to see in the real world, an issue which we address in this section.

3.1 Mapping Virtual Worlds to Real World Phenomena

Clearly several differences exist between a virtual world and the real world; especially when looking at phenomena such as combat. Of most pertinent interest is the fact that players cannot die or experience physical harm in the virtual world. As mentioned before, Game X does not have permanent death.

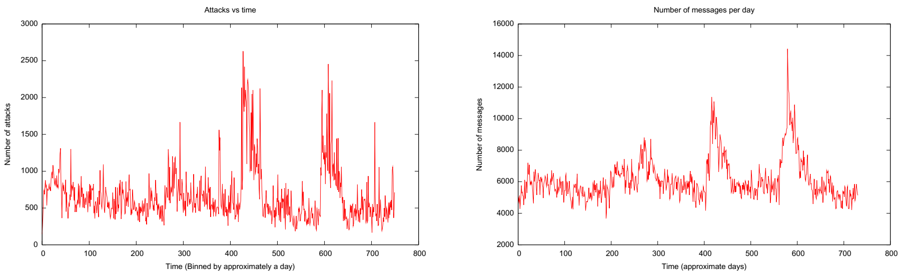
Although these are important issues, we think they are negligible given that players are interested in their characters. Decisions made by the players may not be as emotionally driven (for instance, they may not care if their friends are being harmed), but as long as there is involvement in the characters by the players, their decisions may be driven by the need to preserve their characters' well-being. Since many of the players we have studied have played a significant amount of time, we argue that players are involved. While intensity of emotions will vary (from the real world), the underlying actions are still driven by a need to preserve the character well-being and social relations, similar to the real world.

One may also ask whether players are choosing different persona's or acting differently as they would in the real world. This question is out of the scope of this work but it is a question that is being intensively studied in this general area. Several studies indicate that player characteristics influence player behaviors in the virtual world; for instance, personality traits are correlated with behaviors in game ([8,9]).

4 Large Scale Conflicts in Our MMOG

4.1 Analogues to Real World Large Scale Conflict

Despite some of the issues highlighted in the previous section regarding mapping virtual world to real world phenomena, we noticed very clear analogues between virtual- and real-world LSC. In particular, during both war periods of Game X, we noticed a significant spike in both the number of combat attacks and the number of messages sent, as seen in Figure 1. This is consistent with real-world accounts of conflict, in which participants of armed conflict see an increase in mobilization and coordination for combat.



(a) Number of attacks over Time (b) Number of messages sent over Time

Fig. 1. Combat and messaging patterns throughout the entire Game X data set. The number of combat attacks and the number of messages sent both spike during the periods of war, consistent with real world accounts of conflict.

In addition, our virtual LSC is consistent with real LSC as it relates to the number of participants that participate in combat actions. Specifically, our virtual world LSC exhibits a pattern over the number of attackers that pursue different levels of attacks, which is consistent with the power-law distribution [10] as exhibited in other accounts of participation in armed conflict [11]. This distribution is illustrated in Figure 2.

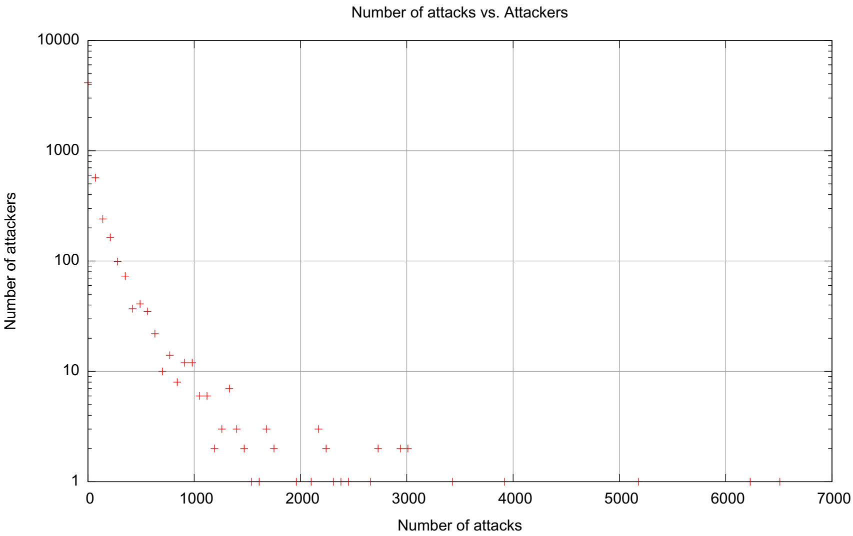


Fig. 2. Distribution of Number of Attacks v. Number of Attackers during the first Game X war. Consistent with other accounts of participation in armed conflict, our virtual world LSC data is well-modeled by a power law.

4.2 Theoretical Framework for LSC Analysis

Given that we identified some parallels to real-world large-scale conflict, we were interested in understanding *a priori* what were the theoretical potential reasons participants would engage in armed conflict. One very influential framework in trying to identify potential reasons, developed by Humphreys and Weinstein [12], analyzed the determinants of participation and non-participation in the civil war of Sierra Leone. Humphreys and Weinstein originally sought to identify which of three "competing" theories better explained insurgent and counter-insurgent participation and non-participation in Sierra Leone. Through their analysis, they found support for all three theories, suggesting that the theories should not be taken in contrast to each other, but rather as an ensemble, capable of identifying multiple influencing factors that affect participation in an armed conflict. One of the three theories was particularly interesting due to its applicability to our game environment: *The Theory of Social Sanctions*. This theory predicts that an individual's participation in large-scale conflict is a function of the community that the individual is a part of. If the community is *strong*, then it can bring to bear a social pressure that will prompt individuals to fight in the conflict on behalf of their respective community. A strong community is (for instance) defined by (1) shared core beliefs and values, (2) close and many-sided relationships between the community's constituents, and (3) activities of reciprocity between the community's constituents [13].

4.3 Behavior of Interest: Dimensions of Combat Behavior as a Function of Community Networks

We operationalized the Theory of Social Sanctions in the context of our game, and were interested in answering the following questions, solely on the basis of an individual's community:

- Will the person engage or not? (i.e. participation)
- Will the person be an active agent in the engagement or not? (i.e. activeness)
- How fast will the person engage? (i.e. time to first response)

Thus, we developed the following set of hypotheses, that are explored in the remainder of this paper.

- ◇ H1: The greater the amount of community participation for a player, the more likely the player will participate in conflict.
- ◇ H2: The greater the amount of community participation for a player, the more the player will participate in conflict.
- ◇ H3: The greater the amount of community participation for a player, the faster the player will participate in conflict.

5 Experimental Methodology

5.1 Operationalizing the Hypotheses

To make some of the hypotheses more precise, we introduced operational definitions for the terms "participation," "community," and "community participation" To be considered a participant of the virtual LSC, an individual had to commit at least one combat action during the war period under study. An individual's community could be defined in three ways; each of them represents a different dimension of interaction between the players of Game X and tried to capture the spirit of the definitions used by Humphreys and Weinstein [12].

Definition 1 (Friendship Community Definition). *Let p and pc be players. For any $pc \neq p$, pc is in p's community if p and pc are bidirectional friends and pc is* not *in p's hostile table. A bidirectional friendship between two players p and pc exists when p is on pc's friend table and vice-versa.*

Definition 2 (Communication Community Definition). *Let p and pc be players. For any $pc \neq p$, pc is in p's community if pc actively communicates with p. Specifically, p and pc are in each other's community if they send and receive at least 4 messages between them during the war period under study.*

The threshold of 4 messages is arbitrary, and was chosen on the basis of the trend of sent and received messages across all players during the war period under study. Specifically, during the first war period, approximately 50% of players had less than 4 messages sent and received.

Definition 3 (Guild Co-Membership Community Definition). *Let* p *and* pc *be players. For any* $pc \neq p$*,* pc *is in* p*'s community if* p *and* pc *belong to the same guild for a majority of the war period under study.*

A natural inclination is to use the intersection of all three communities as a definitive measure of community. However, such a combination did not yield statistically significant results. In addition, we also felt it better to study different types of communities to see whether or not the expected behaviors appeared throughout. Therefore, each hypothesis has three variants, one for each definition of community. Finally, to define community participation, we chose to represent it as the proportion of players within a community that were active during the war period under study. This ensured that the numbers weren't too biased for large communities, by ensuring that all the community participation statistics varied within a common range ($[0.0 - 1.0]$).

5.2 Participants

Our data set includes data for over 50,000 players across >700 days. The data set is historical, beginning in 2007. All participant data has been anonymized and all players agreed as part of Game X's sign-up process to have their data collected for purposes of scientific research. Despite the magnitude of the data, only a small percent of players were actually considered as part of the analysis; several players did in fact sign up, but did not participate enough in Game X to consider their presence meaningful. A great majority of players did not sign-in to play for more than 10% of the entire data set time period. After excluding these players, our participant pool was reduced to 6,156 players. Approximately 13.56% of players were female and 86.44% were male.

Participants of Interest. Our focus was on the first Game X war. After having filtered the data once to remove inactive players, we filtered the data again, this time filtering by two measures: "cumulative actions taken prior to war period" and "log-in percentage". In our description of Game X in Section 2.1, we discussed how players had a limited number of turns per day; "cumulative actions taken prior to war period" is a measure of how many turns they have taken per day across all days prior to the start of the first Game X war. The threshold for consideration was 500,000 turns taken prior to the start of the first Game X war. The reason for filtering by actions taken was because we wanted to control for players who were signing-in and not doing anything, which does not represent the behavior we were interested in studying. The measure "log-in percentage" is defined similarly to how it was defined previously. However, the threshold for consideration was 80% as opposed to the original 10%. These combined filters reduced our participant pool from 6,156 players to 981 players. Of these, approximately 11.62% were female and 88.38% were male.

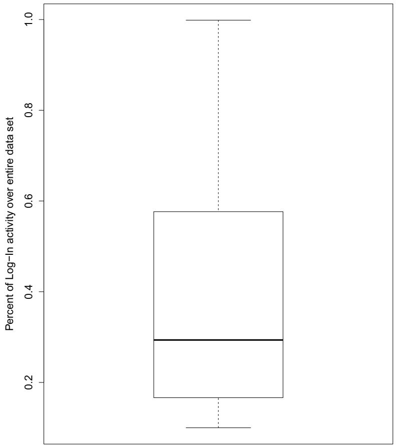


Fig. 3. Box plot of log-in percentage. Log-in percentage is determined by the number of days that players logged in over the total number of days in our data set. We filtered the data for all players whose log-in percentage was less than 10%.

5.3 Hypothesis Tests

Our hypothesis testing was restricted to the first Game X war. For all cases of the hypothesis tests, the variable `communityParticipation` is the proportion of the player's community that was active during the first Game X war. Given the operational definitions, and our hypothesis set, we tested each hypothesis as follows:

- ♢ H1: Likelihood → Logistic Regression of the variable `hadWarAction`, which took value 1 if the player had at least one combat action during the first Game X war and 0 otherwise, over the variable `communityParticipation`. H1 thus predicts that the greater the proportion of `communityParticipation`, the more likely the response variable `hadWarAction` will be 1.
- ♢ H2: Amount → Ordinary Least Squares Regression of the variable `numWarAction`, which is a count of the number of combat actions taken during the first Game X war, over the variable `communityParticipation`. H2 thus predicts that the greater the proportion of `communityParticipation`, the higher the variable `numWarAction` will be.
- ♢ H3: Time to First Attack → Survival Analysis of the variable `timeOfFirstAttack`, which is a number indicating the day the player's first combat action during the first Game X war was registered, over the variable `communityParticipation`. H3 thus predicts that the variable `communityParticipation` will lower the survival function of the variable `timeOfFirstAttack`; in other words, `communityParticipation` will predict how quickly a player commits his or her first combat action as measured by `timeOfFirstAction`;

6 Results and Discussion

The results of our hypothesis tests are shown in Table 1. Survival analysis for H3 did not yield statistical significance for any case, thus we omit the results from the table. We achieved different results under different community definitions, with the communication community not yielding statistical significance for either hypothesis.

Table 1. Hypothesis Test Results

	Community Definitions		
Hypotheses	Guild Community	Friend Community	Communication Community
H1: Likelihood (Logit)	1.633 [0.604]**	-4.703 [0.826]***	0.404 [0.247]
H2: Amount (OLS)	0.669 [1.697]	-9.748 [2.394]***	-1.952 [1.124]

Notes: Standard errors are in brackets. **Significant at 5%; ***Significant at 1%.

The results found indicate a surprising interplay – while friend community participation does *not* affect one's likelihood to participate, your guild community does. This seems to indicate the importance of guild membership and community over other relationships. The non-significant result for H2 with guild community is odd, since from H1 we would assume a greater number of attacks. We posit that a "free rider" effect may be occurring, where individuals in a community may participate, but leave the bulk of combat to others who are better suited for combat. In further work we are looking at the nature of guilds and whether they have a heterogeneous set of players (in terms of skills).

7 Conclusion

Massively Multiplayer Online Games (MMOGs) are a new source of data that help in understanding complex systems. MMOGs serve as a tractable way of analyzing complex social interactions, due to two important features. Firstly, they serve as environments with a high-degree of expressivity, i.e., they allow the participants (also known as "players") to pursue a wide variety of complex social actions, in broad categories such as peer-to-peer and group communication, economic trading, and congregating with other players. Secondly, due to the virtual nature of the environments, MMOG's are able to capture a great amount of data and at high-fidelity, often simultaneously tracking the actions of all individuals in near-real time.

In this report we have compared one particular type of complex behavior, large scale conflict (LSC), in a MMOG (Game X) and in the real world. A high level similarity was seen – a power law distribution of the number of attacks vs. the number of attackers – which corresponds to known patterns in real world conflict. Assessment of community influence on player participation was surprising, as individual friendships did not have a positive influence; however guild communities did.

This lack of correspondence is interesting, and there may be several causes for it. Firstly, the hypotheses we tested were developed (and evaluated) with data from a civil war. This type of conflict may not be as relevant for Game X conflicts. Secondly, there could be a strong "free rider" effect – the more my community is willing to assume the cost of war, the more likely I am going to abstain and "free-ride" on their participation. This could explain the negative interaction for the friend community case. Thirdly, there may be a division of labor within guilds; with some individual being more combat oriented and others more economically oriented. This could explain why there was a positive effect for H1+guild community, but a non-significant effect for H2+guild community – others may be taking on the combat roles.

Further work will focus on addressing these issues to identify the reasons for why players participate in LSCs.

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