The Formation of Task-oriented Groups

Exploring Combat Activities in Online Games

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***Abstract*— Advanced communication technologies enable strangers to work together on the same tasks or projects in virtual environments. Understanding the formation of task-oriented groups is an important first step to study the dynamics of team collaboration. In this paper, we investigated group combat activities in Sony's EverQuest II game to identify the role of player and group attributes on group formation. We found that group formation is highly influenced by players' common interests on challenging tasks. Players with less combat experience are more likely to participate in group events for difficult tasks and team performance is positively correlated to group size.**

Keywords- activity focus theory, bipartite network, group formation, massively multiplayer online game

I. INTRODUCTION

Advanced communication technologies and emerging virtual organizations provide an efficient platform for distributed collaboration. People, even without previous connections, can form a group for a specific task or project and disband when they achieve their goals. Therefore groups are more dynamic and task-oriented, i.e. the group formation does not need to be based on social relations, but can be more related to the common interests and special skills of the participants. Understanding the formation of such task-oriented groups is an important first step in studying the dynamics of team collaboration.

Modeling short-time-span task-oriented groups in the physical world is difficult because each group has distinct tasks and the corresponding skills of the group members are complex and usually not well-defined. In contrast, massively multiplayer online games provide a combat environment with pre-designed tasks and player skill measures. The standard tasks and quantified skills make it possible to study the dynamics of group formation with great precision.

In massively multiplayer online role-playing games (MMOs), player characters form combat groups to defeat monsters and complete quests. During the process, group members get experience points to advance their character levels and build their fighting skills. Game groups are similar to those in the real world in terms of members with similar and, in some cases, complementary expertise collaborating with one another to achieve some collective outcome. Further, the fast changing game environment makes the groups in online games dynamic and short-lived – a feature increasingly observed in the real world. Combat groups are usually formed to complete a set of tasks and get specific rewards. For example, several players may form a group to kill an extremely strong monster or complete a difficult quest together. The group will typically disband after finishing the task. Without pre-determined boundaries, the groups form, change, and disband quickly according to the nature of tasks, ability of player characters, and the changing environment.

In this paper, we use the combat experience data in Sony's EverQuest II game to study how players form combat groups and the impact of player and group attributes on those groups' formation. In the following section, focusing on the activities and coordination in groups, we propose four hypotheses to study the impact of individual and group characteristics on group formation in EverQuest II. Section 3 describes the data set and measures, and Section 4 reports estimation methods and results. Finally, we discuss the findings and implications.

II. THEORIES AND HYPOTHESES OF GROUP FORMATION

Activity Focus Theory [1-4] suggests that individuals group together because of common foci, which can range from places of interest to activities. In online games, foci may include social activities, trading activities, combat activities, places of interest, etc. Any of the above foci can attract a cluster of players and result in interactions between game players. For combat groups in EverQuest II, foci narrow down to combat related activities, such as killing monsters and accomplishing quests. Hence, based on Activity Focus Theory, we propose that the formation of combat groups is driven by combat related activities and not by other types of activities unrelated to combat.

Another important theoretical foundation of our study is the Multi-Theoretical Multi-Level (MTML) Framework [5], which proposes a set of endogenous and exogenous mechanisms to explain individuals' motivations to create, maintain, dissolve, and reconstitute group linkages in a network. Theories of self-interest and theories of mutual interest and collective action in the MTML framework are especially important for explaining the formation of task-focused groups.

Theories of self-interest suggest that people create ties that enable them to maximize their personal achievement. For

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instance, individual players in online games join a group that has members who are stronger and can protect them or who have skills that they don't have. By working with group members, weaker players can defeat strong monsters and accomplish difficult quests. They can also learn fighting techniques from skilled players. So, low level players tend to join groups to seek benefits from others. On the other hand, stronger players who benefit less from the group are less likely to join groups. Based on the theories of self-interest, we propose the following hypothesis.

H1: Players who lack combat ability are more likely to participate in group events than skilled players.

Theories of mutual interest and collective action explain the case when individuals create links and form groups to work together and conquer collective targets that are unachievable by any individual [6]. This family of theories distinguishes from the theories of self-interest in that the theories of mutual interest and collective action predict benefits for all members in a group instead of only for weaker group members. For instance, game players will join groups to fight collectively to defeat a certain monster and collect rewards, which can never be accomplished by any single player. In this case, difficult activities tend to attract more group members than easy activities as predicted by the theories of mutual interest and collective action, because easy activities do not require collaboration of game players.

H2: Players are more likely to join group events for difficult combat tasks.

H3: Players are more likely to join group events for high efficiency.

However, it is difficult to sustain a group for a long time and do many activities together. Once players finish a difficult task and achieve the goal, they may leave and find new groups based on their different interests. Hence we propose:

H4: Long term collaboration is less likely to have many members involved.

III. DATA IN EVERQUEST II

This study analyzed behavioral data of game players from EverQuest II, a major massively multiplayer online game (MMO) in North America with half a million subscribers and 25 game servers. Each player of EverQuest II can create multiple characters and each character can only join one server which operates a virtual world in the game. For most activities, player characters are only allowed to interact with those who are on the same server. Transferring characters from one server to another is not encouraged and requires a charge. Therefore, game servers can be considered as stand-alone parallel virtual worlds with stable populations of player characters.

EverQuest II utilizes an elaborate log system that constantly records data on many individual and collective activities occurred within the game, such as economic transactions, in-game communication, questing, combating, crafting, and so forth. With all identification information removed, a data dump with the total size of 1.14 terabytes was provided directly from the MMO operator and was then stored in an Oracle relational database hosted at a large supercomputing facility at a major Midwestern research university.

In this study, we focus on players' interactions during combat activities, the most essential activity in EverQuest II. We use one week data sample from September 5 to 11 in 2006 from three game servers: Guk, Antonia Bayle, and The Bazaar.

A. Combat Activity in EverQuest II

In EverQuest II, groups are formed to serve three purposes: completing quests, collecting experience points to level up, and seeking rare items. To accomplish the goals the essential group tasks are fighting computer-controlled enemies (called non-player characters, monsters, or "mobs"). This type of player versus environment (PvE) activity is the most common play mode in many MMOs.

To kill monsters efficiently, player characters with different skills need to work together. In EverQuest II, each character can choose a player character class (called PC class) which has a distinct set of fighting skills and strength. PC classes belong to one of four archetypes – Fighter, Priest, Scout, and Mage – and have different roles in group combat activities: fighters are the main "tank" of a group which absorbs the attack damage from monsters and protect other group members; priests are group healers who restore health and strength of group members; mages and scouts use different skills to attack monsters. By combining defending, supporting, and attacking characters, players can implement different fighting strategies.

In addition to the PC classes, each player character can also select one class for their trade skills to craft particular types of in-game items for trade for other desirable in-game items. Some trade classes may increase characters' fighting ability directly. For example, armorers and weaponsmiths are masters to produce armors and weaponry which increase defense and attack ability. Other trade classes such as provisioners and tailors are not related to combats and they produce virtual items for fun or for sale in exchange of in-game currency.

The PC and trade classes set the general paths for players to develop their characters that thrive within individual game servers. And each game server may have special settings to promote some activities. The servers we test in this study belong to three different types. Guk is a regular PvE server. Although having the same game maps and PvE activities, Antonia Bayle encourages role play activities in which players immerse themselves fully in a game and become their characters and bring them to life. The Bazaar has the option of buying or selling game commodities and has an active population of traders.

B. Groups in EverQuest II

In the world of EverQuest II players are encouraged to form "groups" to play together in order to complete difficult tasks. The notion of a group is well defined as an in-game feature where players have the option to invite others to join them to form a group. These groups can then perform various in-game tasks together and the game software ensures that any rewards and experience points gained during this period are shared by all the group members. The tasks can range from simple to elaborate quests, players' guild operations, and pretty much anything under the umbrella of shared personal goals. Depending upon the difficulty of the tasks, group sizes can range from 2 to 24 members. Apart from providing a mechanism for collaboration for in-game tasks, the group feature also provides a platform for players to develop their own private social cliques.

Explicit information regarding groups and their members is not available in the game logs. However, activities of the game players leave digital traces in the log files and make it possible to recover group information from available log data. Whenever an individual kills a monster in the world of EverQuest II, the player is rewarded with experience points. The quantity of experience points gained depends upon the difficulty of killing that monster. These experience points are vital to leveling up player characters. This data for all player characters in game servers is available in the experience log file.

Players in the same group share experience points i.e. whenever one or several group members kill a monster (called one "group activity"), all group members in the area of the killed monster share the gained experience points for the kill. These experience points gain show up as individual entries, one for each group member, in the experience log file. Each entry include several fields, including a sequence id, time stamp, location id, group size, group level and reason (i.e. reason for gaining experience points, consisting of the name of the monster killed). The next kill made by the group will be recorded by the system as another set of records in the experience log file.

Entries incurred by multiple members of a group in the same activity have consecutive record sequence ids and share the same time stamp, location (where the monster was killed), group attributes, as well as the name of the monster killed, even though the experience points for each group member might be different, which help us to identify group members conducting the activities. In one group event, players usually conduct multiple activities over a period of time. In order to recover groups and their members from numerous entries in experience log files, we first identify group activities, and then stitch the same group's records together. Group activities will be identified as contiguous if they have fewer than 60 minutes of intermediate inactivity. If the interval is longer than 60 minutes, new activities will be considered as a part of a new group event instead of the previous group event.

Figure 1 summarizes the algorithm of group event stitching. First, we removed records logged by gold farmers from the experience log file based on the list of banned players due to gold farming activities. Then, we sort the clean records by the following fields in order: time stamp, location, and record sequence id. This ensures that records of the same group activity appear one after the other in the sorted records. Then, we analyzed the sorted records and parsed consecutive records with the same time stamp, location, group size and group level to recover group event activities. Next, we produced group events by aggregating all group activities that have the same members and have less than 60 minute gaps between their time stamps. Finally, an unweighted and undirected bipartite graph is constructed where the two types of nodes represent player characters and group events. Corresponding attributes are aggregated at the group event level.

Input: A character combat log with time stamps.
Output: A bipartite network of characters and group events

1. Group Activity Detection:
 for each character activity record **do**
  Find consecutive records with the same time stamp, location, group size, and group level
  Link all matching records and add to ActivityList
 end for
2. Group Event Stitching:
 for each group activity in ActivityList **do**
  If the activity has the same set of characters as one group event in EventList and the activity happened within 60 minutes from the event ending time,
  add this activity to the group event,
  otherwise create a new group event for the activity.
 end for

Figure 1. Group Event Stitching Algorithm

The whole game world in EverQuest II is very large and is organized into separated geographical regions (called zones). Each zone is either a continent or a collection of connected islands in the virtual world and there are only a few connections among the zones. Based on the zones where group events occurred, we separate the whole event network into 14 zone-based samples for each server. In total, we have 42 data samples and each of them only includes the characters and their group events in one zone on one server. Table 1 summarizes the names of the 14 zones and the statistics of the group event networks.

C. *Measures*

We develop six variables to measure the attributes of player characters and three variables to measure group statistics:

- Character classes: We use four dummy variables, *Class_fighter*, *Class_priest*, *Class_scout*, and *Class_mage*, to indicate characters' archtypes in EverQuest II.
- Combat ability: Player character class level (*PC_class_level*) is a measure of player's combat ability in the game. Starting at level 1, a character needs to collect experience points from fighting monsters and increase its level up to level 70. Advancing class levels is one of three major objectives for participating in group combat activities.
- Trade skills: *Trade_level* measures the level of a character's trade skill from level 1 (lowest) to level 70. The trade class is developed through non-combat activities such as trading quests and is independent of PC class level.

- Task difficulty: A group may choose easy tasks or challenges according to their objective. To estimate the difficulty of group tasks, we use a binary variable *Member_death* which equals to one if there is at least one member dead during group activities.

- Event duration: *Event_duration* measures the total length of a group event in minutes.

- Experience point efficiency: A group of characters perform many activities together and share experience points earned. *XP_efficiency* measures group performance using the average experience point earned per minute, i.e. the total number of experience points gain divided by the event duration.

D. Descriptive Statistics

We identified 8,895 unique characters and 12,024 group events in the 42 zones during the one-week sample period. The numbers of characters and group events are reported in Table I and the statistics are in Table II.

TABLE I. NUMBERS OF CHARACTERS AND EVENTS BY ZONE & SERVER

Zones	Guk		Antonia Bayle		The Bazaar	
	Char	*Event*	*Char*	*Event*	*Char*	*Event*
Antonica	465	396	808	808	731	618
Commonlands	380	315	555	550	293	277
Desert of Flames	499	518	510	502	364	383
Everfrost	211	165	214	167	190	145
Fallen Dynasty	133	41	102	27	112	26
Feerrott	269	206	346	339	184	175
Freeport	94	66	154	105	83	44
Kingdom of Sky	625	436	557	498	404	361
Lavastorm	198	141	237	166	112	73
Nektulos Forest	287	161	332	177	231	124
Qeynos	115	53	301	202	269	212
The Enchanted Lands	530	537	544	479	354	299
Thundering Steppes	639	591	786	813	568	460
Zek	170	81	239	169	180	118

TABLE II. STATISTICS OF CHARACTERS AND EVENTS

Variables	*Min.*	*1st Qu.*	*Median*	*Mean*	*3rd Qu.*	*Max.*
Class_fighter	0	0	0	0.3011	1	1
Class_priest	0	0	0	0.2573	1	1
Class_scout	0	0	0	0.2534	1	1
Class_mage	0	0	0	0.1882	0	1
PC_class_level	1	24	40	39.72	57	70
Trade_level	1	4	17	21.68	33	70
Event_size	3	3	4	4.269	5	24
Member_death	0	0	0	0.4234	1	1
XP_efficiency	0	291	553	739.4	988	14357
Event_duration	1	5	14	25.62	33	500

There are 2,678 fighters, 2,289 priests, 2,254 scouts, and 1,674 mages. The correlation between *PC_class_level* and *Trade_level* is 0.56. On average each group event has 4.269 members, lasts 25.62 minutes, and earns 739.4 experience points. Figure 2 illustrates the group event network in Antonia on server Guk. Black squares indicate group events and the size represents the group efficiency. Grey circles indicate characters and the size indicates their PC class levels.

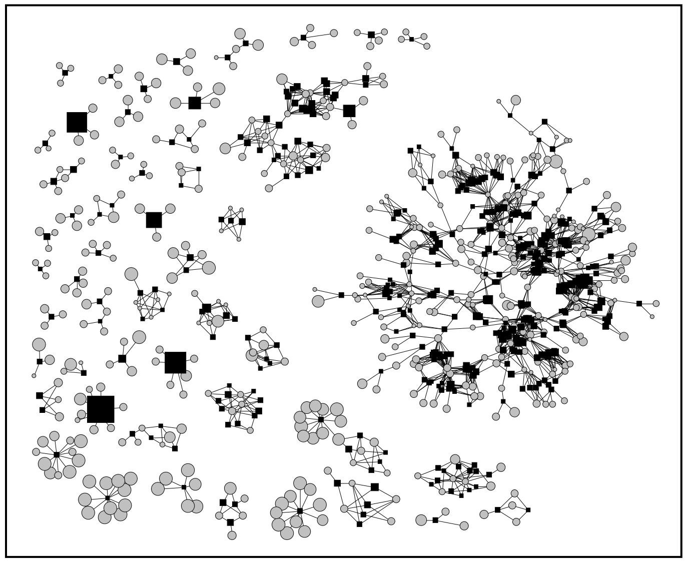

Figure 2. Character-Event Bipartite Network in Antonica on Server Guk

IV. MODEL AND RESULTS

A. Methods

The network data used in this study pose significant analytic challenges. Traditional statistical techniques assume that observations are independent. However, an observation about a network link is not independent of the other links. Although the lack of independence in network data has been widely recognized, researchers have often resorted to using traditional statistical techniques due to the lack of appropriate analytic techniques until recently. This study addressed this methodological weakness by employing a recently developed set of techniques called Exponential Random Graph Models (ERGM) or p* models [7-9]. ERGM offers an opportunity to explain networks based on multiple levels of analysis ranging from the individual, dyadic, triadic, to the group level. This makes ERGM particularly appropriate for this study because this study attempts to examine network structures at the individual, dyadic, triadic, and even higher levels.

There are two stages for investigating network structures with ERGM. The first is parameter estimation. This study employed Markov Chain Monte Carlo maximum likelihood estimation (MCMCMLE) as recommended by [10]. This method provides more reliable standard error estimates, though there may be difficulty in reaching converged models. The second step is the diagnostic "goodness of fit" examination. Once the parameter estimates are obtained from the observed network, a large number of networks are simulated based on these estimates. If the estimates accurately capture the structural characteristics of the observed network, the observed network should be very likely to occur within the distribution of simulated networks. If the estimated model does not fit the observed network well, the observed network will have a much lower probability of occurring in the distribution of simulated networks.

Wang, et. al. [11] generalized the basic ERGM/p* to affiliation networks. Affiliation networks, also called bipartite networks, consist of two or more sets of nodes, each of which represents a different social entity, and the relational links between these nodes of different social entities. In this study, the two different types of nodes are the player characters in the game and the group events these characters formed during their game play. The relational links between the characters and the group indicates group membership. Therefore, if there is a link between Character A and Group Event 1, it means that Character A is a member in, or belongs to, Group Event 1. Specifically, the program BPNet [11] was used to test the hypotheses. For most groups, if the convergence statistics of all of the structures in the model are below 0.1, it is considered a converged model. In the converged models, parameter estimates that are at least twice of their standard error are considered statistically significant.

B. Analysis

We use Exponential Random Graph Models (ERGM) for bipartite networks [11] to examine the hypotheses and test the likelihood that a link or other network structures will exist between characters and group events in a network.

For Hypothesis 1, we use PC class levels and trade levels to represent characters' combat ability. In general the longer a character has played in EverQuest II, the higher his or her level is. Therefore, the hypothesis implies that the characters with lower levels are more likely to participate in group events. However, different from the PC class level, the trade level may not be an accurate measure of combat ability because some trade skills have no direct connection with fighting.

The members in a group are more likely to fail and die while doing challenging tasks. Therefore we use whether there are members dead during the group event to measure the difficulty of combat tasks in Hypothesis 2.

For Hypotheses 3 and 4, we use *XP_efficiency*, experience points earned per minute, as a measure of group efficiency and use event duration to estimate the length of group collaboration.

Taking the fighter class as the base, we use three dummy variables *Class_priest*, *Class_scout*, and *Class_mage* to control the different roles of player character classes.

During the one week sampling time period, each player character may participate in many group events with a different number of other players. We use three network statistics to model these network structures: Edge, which equals to the number of group membership in a network, controls the density of the network; Character Alternating K-Star, equivalent to geometrically weighted characters' degrees, controls the popularity of a character; and Group Alternating K-Star, geometrically weighted groups' degrees, controls the number of members in a group event. The model is estimated using BPNet and the results are summarized in the following tables.

C. Results

For the 14 sample zones on the Guk server, the BPnet estimation results are consistent across ten samples. Four zones have either less than 100 characters or less than 100 events and do not have significant results for most variables. Table III summarizes the results of three zones in server Guk: Antonica (one of the earliest zone in EverQuest II), Kingdom of Sky (the newest zone in EverQuest II), and Thundering Steppes (the most active zone on Guk during the time period).

TABLE III. BPNET ESTIMATION RESULTS FOR SERVER GUK

Variables	**Server Guk**		
	Antonica	***Kingdom of Sky***	***Thundering Steppes***
PC_class_level	-0.012* (.002)	-0.02* (.003)	-0.0076* (.001)
Trade_level	-0.0052* (.002)	-0.0016 (.0008)	-0.0040* (.001)
Member_death	0.47* (.12)	0.31* (.007)	0.37* (.10)
XP_efficiency	0.00026* (.00005)	0.00017* (.00004)	0.000985* (.00008)
Event_duration	-0.0042 (.002)	0.0023* (.0009)	-0.0046* (.002)
Class_priest	0.027 (.05)	-0.016 (.04)	0.032 (.04)
Class_scout	-0.020 (.06)	0.050 (.04)	-0.024 (.04)
Class_mage	-0.025 (.06)	-0.029 (.05)	0.061 (.04)
Edge	5.06* (1.11)	1.25 (.81)	7.63* (1.05)
Char_kstar	0.78* (.07)	0.86* (.05)	0.88* (.05)
Group_kstar	-6.12* (.61)	-3.48* (.42)	-8.02* (.06)

* indicate twice of standard deviation

From the character side, player character class level has a significant negative impact on group formation in nine of the ten zones on Guk. The players at lower levels are more likely to form groups and fight together. Hypothesis 1 is supported. Similarly player trade class levels also have a negative impact in seven of the ten zones. These results suggest that players who lack combat ability are more likely to participate in group events than skilled players.

On the group event side, the positive coefficients of *Member death* (significant in eight of ten zones) suggest when the tasks are intense players are more likely to form a group. Hypothesis 2 is supported. This shows that the primary goal of forming combat groups is to work together to complete difficult tasks. As predicted by Hypothesis 3, the group efficiency has a positive impact on group formation. The groups earning more experience points per minute are likely to have more members.

Event duration has a significant negative impact only in four of ten zones. There is no strong evidence to support Hypothesis 4. Working together in one group event for a long time may not influence the number of group members involved.

The positive coefficients of Character Alternating K-Star indicate that when a character's geometrically weighted degree count is high, i.e. joined many events, he is more likely to join other events compare to the one with low weighted degree count. Negative coefficients of Groups Alternating K-Star suggest that a group event with more members is less likely to have new member compared to smaller events. In words, characters tend to play in many group events and each event only has relatively small number of players involved.

The analyses using other 28 zones on servers Antonia Bayle and the Bazaar show the similar results and support Hypotheses 1, 2, and 3, but not Hypothesis 4. The only difference is that the negative impacts of *Trade level* are significant only in five out of 28 zones. The results of zones Antonica and Kingdom of Sky on servers Antonia Bayle and The Bazaar are reported in Table IV.

TABLE IV. RESULTS FOR SERVERS ANTONIA BAYLE & THE BAZAAR

Variables	**Server Antonia Bayle**		**Server The Bazaar**	
	Antonica	***Kingdom of Sky***	***Antonica***	***Kingdom of Sky***
PC_class_level	-0.024*	-0.016*	-0.015*	-0.0026
Trade_level	0.00013	-0.0013	-0.0043*	-0.0017
Member_death	0.31*	0.28*	0.26*	0.23*
XP_efficiency	0.00013*	0.00040*	0.00014*	0.00073*
Event_duration	-0.0025	-0.0050*	-0.00047	0.0019
Class_priest	-0.057	0.046	0.12*	-0.033
Class_scout	-0.15*	0.0048	-0.029	-0.0034
Class_mage	-0.036	-0.017	-0.0047	-0.085
Edge	4.42*	5.23*	3.73*	8.20*
Char_kstar	0.85*	1.09*	0.56*	0.47*
Group_kstar	-5.85*	-6.52*	-5.40*	-7.95*

* indicate twice of standard deviation

V. DISCUSSION AND CONCLUSION

As the preliminary results show, the combat group relation in online games is tied with specific types of combat activities. Players with the same interest form a group, finish a set of tasks together, and disband. The group foci play an important role on group formation.

Similar to the off-line groups, players who lack ability (in this case, in combat) are more likely to work together and form a group, especially when they are facing challenging tasks. More efficient groups are often associated with more members.

The inconsistent results on trade levels between Guk and two other servers suggest that it is critical to accurately measure individuals' ability related to group foci. In Guk, a regular PvE server, most of activities are centered on fighting monsters and people develop trade skills to build armor and weapons to increase their fighting ability. Therefore trade levels can reveal people's motivation to form groups. However, trade skills cover a much broader spectrum of interests in Antonia Bayle and The Bazaar such as character role playing and crafting for sale. In this case trade levels fail to explain the process of forming combat groups.

In this study we did not find evidence of coordination cost (Hypothesis 4). Once groups are formed, large groups do not play for significantly shorter duration than small groups. We focus on group events in this study and the duration of group events may be determined by the nature of tasks and not members' coordination.

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