Do public interaction networks reflect private interaction?

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ABSTRACT

Social media (such as Facebook, Twitter) has allowed researchers to induce large social networks from easily accessible online data. However, relationships inferred from social media data may not reflect real world interaction. The main question of this work is: How does the public social network reflect the private social network? We begin to address this question by studying public and private interaction between players in a Massively Multiplayer Online Game (MMOG). Our data set consists of post players write in a public forum, and the behaviors of players in the game. The posts are the public aspect (similar to getting data from social media), and the actual behavior and characteristics of the player the private aspect. We find that public interaction can reflect private, person-to-person interaction.

1. INTRODUCTION

Social media (such as Facebook, Twitter) has allowed researchers to induce large social networks from easily accessible online data. However, relationships inferred from social media data may not reflect real interaction. First, individuals interact with social media understanding (to a certain extent) that it is a public forum for communication, and thus may limit what they say. Secondly, the relations expressed may not represent the full set of relations an individual has in the "real world". One may have friends who do not use Facebook, and thus that relationship is missing. Thirdly, extraneous relations may be present in social media that do not occur in the real world. For instance, I may "follow" the twitter account of a celebrity, but that is not a real indicator of a relationship.

In many cases, what we want is the "private" social network that identifies strong relationship in the real world. We can view the social network from social media as reflecting some of the relationship from the real, hidden, private network. Figure 1 illustrates some of the difficulties when inferring private networks from public networks.

The main question of this work is: How does the public social network reflect the private social network? We begin to address this question by studying public and private interaction between players in a Massively Multiplayer Online Game (MMOG). Our data set consists of post players write in a public forum, and the behaviors of players in the game. The posts are the public aspect (similar to getting data from social media), and the actual behavior and characteristics of the player the private aspect.

Our goal is to understand whether interacting publicly (on the public forum) means that players are interacting privately. We find that if players communicate with each other publicly (through co-posting), they are likely to also be communicating privately (through the in game email system).

We also find that certain relationships do not show up in public communication. Surprisingly, friendship relationships within the game are not reflected in public relationships.

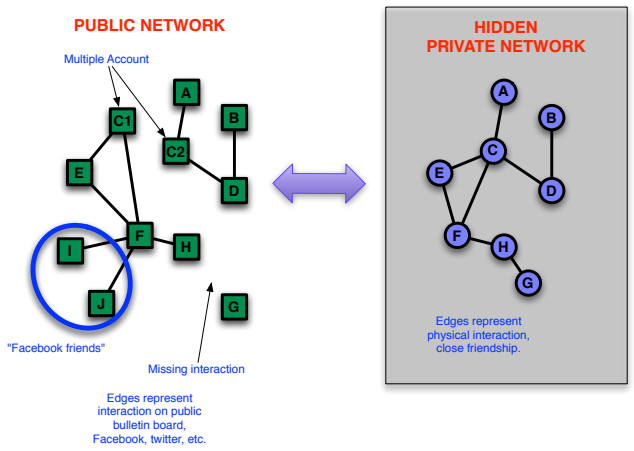

Figure 1: Private vs. public networks. Public networks can often have multiple accounts for the same RL person, and extraneous or missing edges.

1.1 Why MMOGs?

Massively multiplayer online games are online games that attract millions of players to a shared, virtual world. Many varieties of online games exist, some popular to a wide audience, such as *Farmville*, others that are less widely known, like Second Life, World of Warcraft, or Eve Online. While the term MMOG may encompass a variety of genres, we are interested in the large portion of games that are often labeled "role playing games". In these, players create an

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avatar that represents them in the virtual world[1].It is this genre that we specifically discuss in the following.

Some games have objectives and quests in order for the player to gain experience and skills (e.g., World of Warcraft), whereas others have an open-ended world in which all content is created by the players (e.g., Second Life). Still others are in the middle of this spectrum, providing means to gain wealth, power and experience, but allowing for open ended play within the universe (e.g., Eve Online).

MMOGs are appealing for their complex economies and social structures. Many of the games contain player created and controlled "guilds" or "corporations" which players can join. These groups regularly have conflicts and interactions in the world. In some instances, long term (approximately a year of real world time) espionage has been conducted [3]!

MMOGs have several advantages as a method of gathering data.

Number of subjects MMOGs have thousands to millions of players. Recent data indicates that more than 21 million active accounts on various MMOG games [1].

Diversity Contrary to popular belief, MMOGs have a wide array of player types. A study conducted with 30,000 players [11] indicated a mean age of 26.57 with a range of 11-68. In addition, both genders were represented.

Realism MMOGs are high in experimental realism [7], as players willingly spend hours playing (on average 22 hours per week [11]), however they clearly lack in mundane realism. It's still an open question as to whether they have psychological realism.

Dynamics MMOG data can be captured over years; events in game often occur faster than in the real world so one can see the rise and fall of organizations within the game.

Manipulation MMOGs can be observed passively, since they are naturally instrumented. Platforms are being built with the intent of manipulating the environment though [8].

Privacy All data is generated in a virtual world, so most privacy concerns are minimal.

Domain MMOGs have a unique capability to observe communication and behavior of players. In-game forums and messaging data can be gathered along with behavior. This gives us one way of addressing the "radical chic" problem, by explicitly studying the correlation between communication and behavior.

Commitment MMOGs are still games, and player decisions do not affect their real lives. However, players do invest much time into their avatars and have strong emotions regarding said avatars. We believe this leads to players wanting to protect their avatars, making their level of commitment to behaviors stronger. An example of long-term commitment can be found in [3].

The main criticism against MMOG data is that player behavior in-game is not the same as real-world behavior[2]. This is an ongoing endeavor, but we can point out a few studies that show some similarity. Studies have shown how real-world personality traits are linked to in-game behavior. In [12], the authors conducted tests on the Big-5 personality traits on 1,040 *World of Warcraft* players. They also tracked player behavior over a 4 month period. Statistically significant correlations were found between player behavior and personality traits. These correlations also seemed to make sense. For instance, players who scored high on "Extroversion" tended to exhibit behavior that required collaboration with other players, such as group quests.

This study indicates the potential for seeing personality traces in game. This implies that players behavior in game reflects their innate characteristics.

Since many MMOGs contain complex social and economic systems, it is possible to construct economic indicators as well. In [2] the authors looked at economic data from the large virtual world *EverQuest 2* (EQ2). This work is interesting as it shows the potential when using MMOG data. The authors had data on all the trades and interactions between buyers and sellers for several years. They found that the in-game economy follows real-world patterns.

1.2 Related Work

Recently there has been much work on evaluating *tie strength*, the general sense of closeness between individuals [5, 4]. The general idea in these models is to identify characteristics between individuals that can predict how close individuals are. For instance, in [5], the authors used data from facebook, such as number of wall posts, number of inbox messages, days since last communication, number of mutual friends, and several others to predict tie strength. Tie strength was measured by surveying individuals about their relationship with specific individuals.

Our work is similar, although we are mainly interested in predicting player actions and characteristics. For instance, our interest lies in understanding if players who communicate publicly are more or less likely to trade with each other.

1.3 Method Overview & Research Questions

Our research question is:

Does public interaction (such as posting on public forums) reflect private relationships (such as private communication)?

To answer this question, we will look at data from an MMOG. Our data set contains posts by players in an Usenet like public forum within the game. We compare interaction in this public forum with interaction within the game.

Section 2 provides an overview of our MMOG. Section 3 outlines our data collection and the metrics we use to measure interaction and overlap.

2. DESCRIPTION OF GAME X

Game X is a browser-based exploration game which has players acting as adventurers owning a vehicle and traveling a fictional game world. There is no winning in Game X, rather players freely explore the game world and can mine resources, trade, and conduct war. There is the concept of money within Game X, which we refer to as marks. To buy vehicles and travel in the game world players must gather marks. There is a vibrant market-based economy within Game X.

Players can communicate with each other through in-game

[1]In the following we use the term "players" to refer to the avatars within the game.

[2]The "mapping principle" [10] is a term used to describe which behaviors in virtual space "map" to the real world.

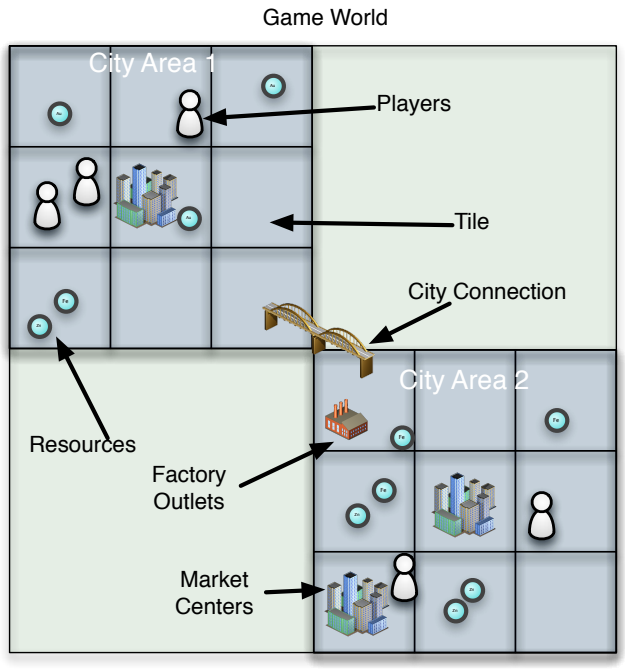

Figure 2: Schematic overview of the Game X world.

personal messages, public forum posts and in chat rooms. Players can also denote other players as friends or as hostiles. Players can take different actions, such as:

1. Move vehicle
2. Mine resources
3. Buy/sell resources
4. Build vehicles, products, factory outlets
5. Fight Non-Player Characters (NPCs)
6. Fight other players

Players can use resources to build factory outlets and create products that can be sold to other players.

Unlike other MMO's like World of Warcraft (WoW) and Everquest (EV), Game X applies a "turn system". Every day each player gets an allotment of "turns". Every action (except communication) requires some number of turns to execute. For instance, if a player wants to move their vehicle by two tiles, this would cost, say, 10 turns. Turns can be considered a form of "energy" that players have.

The use of turns has two major impacts:

1. Players with varying time commitments can play together. Since everyone is limited to the same amount of actions per day players with minimal time on their hands are less disadvantaged than in other games. In contrast, in WoW player leveling and experience can depend highly on the amount of time they play (e.g., "grinding").
2. Players have to think about their moves ahead of time. Because there is a limit on turns, players must think and plan ahead before making their moves.

Figure 2 is a schematic depicting the playing space of Game X . Players move from tile to tile in their vehicles. Tiles can contain resources and/or factory outlets and market centers. Only one factory outlet/market center may exist on a tile. The world is 2D, and does not wrap around.

Players can gather resources from tiles and sell them to market centers. Factory outlets allow the creation of new goods from resources – e.g., producing steel from iron ore. More advanced factory outlets exist which can create more advanced objects, e.g., taking steel and producing a sword. Gathering resources and selling to factory outlets is the main way of gaining marks in Game X .

Factory outlets and market centers can be built by players. Creating these structures is relatively straightforward and does not take much in terms of marks or experience. The difficulty lies in maintaining the structures. In order to prosper, the structures require certain resources. Once built, supplying your structures with the necessary resources can be time consuming. Joining a guild (see below) can be helpful as members of the guild can supply your structure.

Players can also engage in combat with non player characters, other players, and even market centers and factory outlets. Players can modify their vehicles to include new weaponry and defensive elements. Players have "skills" that can impact their ability to attack/defend.

2.1 Groups in Game X

There are four types of groups a player may belong to. Table 1 summarizes the properties of these.

Nations

There are three nations a player may join. We label them A,B, and C. A player may choose not to join a nation as well.

Nations are fixed and defined by the game creators. Nation membership is *open*, players may join any nation they wish at any time and leave at any time.

Joining a nation provides several benefits:

1. Access to restricted, "nation controlled" areas.
2. Access to special quests.
3. Access to special vehicles and add-ons.

Nations have different strengths; one nation may be better suited for weaponry, and thus have more weaponry related add-ons. Another may be suited for trading.

Completing quests for a nation increases a player *stature* towards the nation – which leads to access to special vehicles and add-ons.

Wars occur between nations.

Agency

An agency can be thought of as a social category. There are two agencies, X and Y. A player can only be a part of 1 agency at any time. To gain membership to an agency certain requirements need to be met, but if those are met anyone can join the agency.

Certain vehicles are open to particular agencies.

Race

Player may chose their race when they create a character. Different races have strengths in certain areas, implemented as different initial levels of skill. Race is fixed and cannot be changed once chosen. Race also determines starting location.

Race does not seem to play a strong role in the dynamics of the game.

Guild

Game X also allows the creation of player led guilds. These guilds allow members to cooperate to gain physical and eco-

Figure 3: Forum structure in Game X . Each forum can have multiple topics, and each topic can have multiple posts.

nomic control of the game world. Guilds are comprised of a leader and board who form policy and make decisions that impact the entire guild membership.

Guilds can be created by any player once they have met experience and financial requirements. Guilds have a minimum membership of 1, and no upper limit on size.

Apart from the officers, there are the "privileged guild members" a special set of guild players who are considered important. Finally there are the regular guild members.

Guilds are *closed* – players must submit an application and can be denied membership.

Guild members have access to private communication channels.

Guilds have a "guild account" which can store marks from players (taken in the form of taxes). These marks can be redistributed at the will of the CFO.

2.2 Communication in Game X

Game X includes 3 methods by which players can communicate with each other:

1. Personal Messages: An email like system for communicating with other players, or in some cases groups of players.

2. Public Forum: A Usenet like system in which players can post topics and replies (see below).

3. Chat: An IM like system for players to chat with others in their guild.

The structure of the forums are shown in Figure 3.

Each forum posts includes the name of the player who posted an image of their avatar in the game, and their guild affiliation.

3. METHOD

3.1 Forum based measures

We have data on more than 700 days from the game. Included in this dataset are posts from 7 different forums within the game. One of the forums is meant for role playing (RP) discussion, that is all players must discuss in the role of their character. One forum is meant for Non-Role Playing discussion (NRP). The rest of the forums are both RP and NRP.

Table 2 provides some high level statistics of the forums. We can see that forum 2, which was only RP, was the most popular in terms of posts. However, the number of topics was low – indicating higher average topic lengths (that is, higher average number of posts per topic).

Figure 4 shows the posts per day over the entire time period of the dataset. We chose the 50 day time period starting from day 500 as our evaluation period. This time period had a relatively stable rate of posts per day, new players per day, and active players per day. Our goal was to reduce the impact of posting behavior from "newbies".

There are three ways of communicating with others on the forum:

1. Create a new topic.

2. Post on a topic created by another player.

3. Post on a topic and quote another player.

In this work we only consider the second type of public interaction, which we call "co-posting".

Definition 1. **Co-posters** The *co-posters* of a player p are all players who have posted in a topic that player p has also posted in.

In Figure 3 players p1 and p2 are co-posters, as are p0 and p1; and p0 and p2 because they all have posted on the same topic (t0).

We choose to study co-posting because it directly encodes participation in a conversation and it can be measured in many types of social media.

Usenet type discussion boards, due to their similarity to the forums in Game X , will have a notion of co-posting. Facebook discussions or comment streams can also be analyzed for co-posting behavior. Comment threads (for instance in the social bookmarking/commenting site Reddit) can also be analyzed for co-posting behavior.

We constructed the co-poster network, denoted by $G_{cp} =< V, E >$ by calculating the co-posters for every player during the evaluation period of our data set. The vertices in the network are players, and an edge exists between vertices if either of the players are a co-poster to the other. The edges are undirected. Each edge is weighted by the number of topics that both players posted on. So a value of 5 would indicate that the two players have both posted on 5 different topics during the evaluation time span. Self edges were removed – thus orphan topics (with no other posts except the original), were not counted.

Table 3 has an overview of the network measures of G_{cp}. Figure 5 shows the degree distribution of the co-posting network. As can be expected, there are many individuals that only have a single co-poster (indicating topics with only 2 posts). There are several people with a high degree. This was most likely due to participation in topics with many posts that spanned many months.

	Nation	Agency	Guild	Race
Number:	Fixed, 3	Fixed, 2	Dynamic, Many	Fixed
Membership type	Open	Open (req's)	Closed	Open
Modifiable	Yes	Yes	Yes	No

Table 1: Summary of properties of the groups in Game X

Forum	# Posts	# Authors	# Topics	Posts/Topic
1 (NRP)	16847	1494	**2468**	6.8
2 (RP)	**62669**	**2244**	1813	34.6
3 (NRP/RP)	35069	1909	1240	28.3
4 (NRP/RP)	9544	1391	223	**42.8**
5 (NRP/RP)	11047	1424	2091	5.3
16 (NRP/RP)	13326	1497	875	15.2
7 (NRP/RP)	1778	341	286	6.2

Table 2: Overview of post/authors/and topics for each forum. Bold entries are the max values for the column. These are calculated over the entire 700 day period.

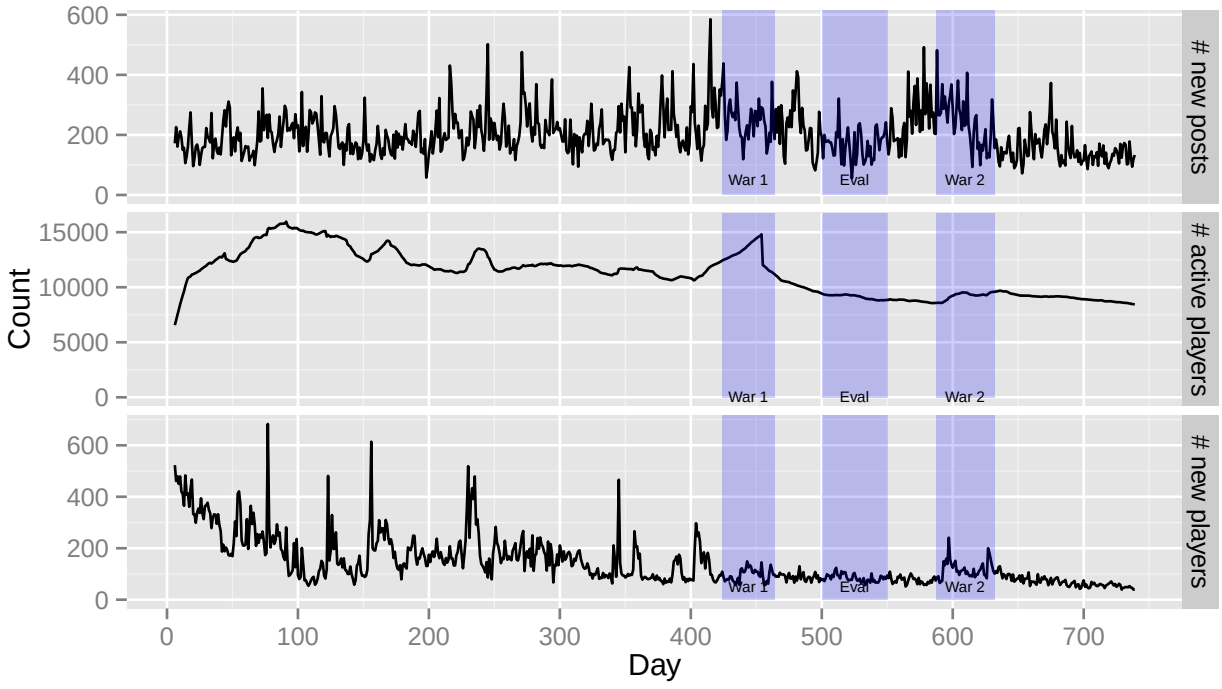

Figure 4: New Posts per day from day 5 to day 739. Highlighted time periods indicate the two wars and the evaluation period.

Measure	Value
Vertices	722
Edges	31381
Clustering Coefficient	0.4839
Degree Assortativity	-0.2241
Mean Path Length	2.0309

Table 3: Network measures for G_{cp}, the network of co-posters.

3.2 Private Action Measures

For each edge in the G_{cp} we measured the following variables between the players p_i and p_j:

Friendship Are either of the players friends of each other?

Hostility Are either of the players hostile to each other?

Personal Messaging How many personal messages occurred between p_i and p_j? (threshold of 5)

Trades How many trades occurred between p_i and p_j? (threshold of 5)

Nation Are the two players part of the same nation?

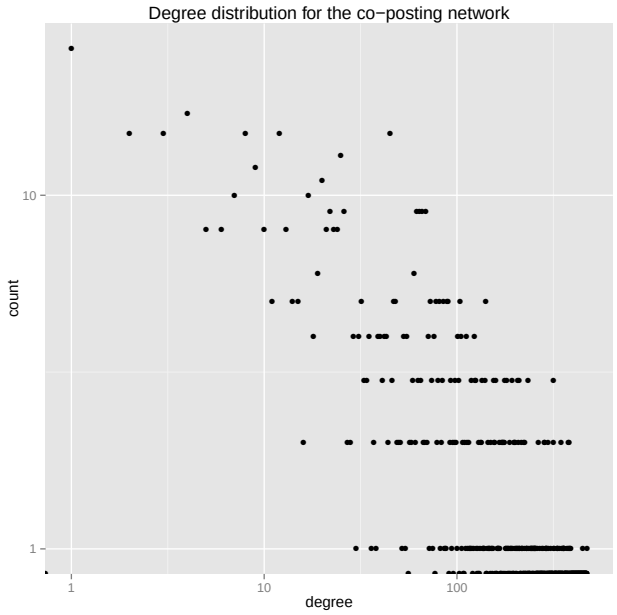

Figure 5: Degree distribution of the co-posting network on a log-log scale.

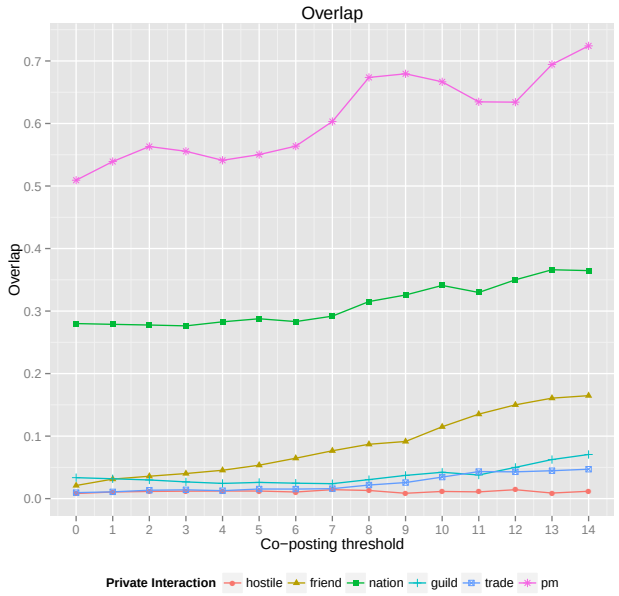

Figure 6: Link overlap between co-posting and private interaction measures.

Guild Are the two players part of the same guild?

We listed two players as *communicating* via personal messages if they sent and/or received more than 5 messages. We listed two players as *traders* if there have been more than 5 trades between the players. These thresholds were set in order to remove spurious relationships.

The *link overlap on relationship* R is the percentage of players who are co-posters and have the relationship R. For instance, a link overlap of 0.7 on relationship "Friendship" means that 70% of co-posters also were friends.

Recall that several of the topics had hundreds of posts. In these cases it may be that players were responding to long running topic (such as a feature proposal topic). Co-posting on such a topic may not indicate a relationship between players. To address this, we calculate the link overlap by only considering pairs of players who had co-posted on several topics – i.e., filtering edges based on edge weights.

More precisely, let $N(x)$ be the set of all edges (pairs of nodes (i, j)) in G_{cp} such that the weight on the edge is greater than or equal to x. The link overlap for co-posting threshold x is defined as:

$$L(x) = \frac{1}{|N(x)|} \sum_{i,j \in N(x)} M_R(i, j)$$

Where:

$$M_R(i, j) = \begin{cases} 1 & \text{If (i,j) satisfy the relation } R \\ 0 & \text{otherwise} \end{cases}$$

$M_R(i, j)$ represents the private action measure R. For instance, $M_{friendship}$ is 1 if the two players i and j are friends. $M_{communication}$ is 1 if the two players had exchanged more than 5 messages.

4. RESULTS AND DISCUSSION

Figure 6 shows the link overlap for different co-posting thresholds.

We can see that nation affiliation had a steady overlap value of approximately .255 and peaking at 0.355. Nations do play a role in the large scale conflicts that take place in Game X . The evaluation time period started 40 days after the end of the first war, so it is possible that nation affiliation was still an important attribute. Another factor with nation affiliation: there are only 3 nations (plus unaffiliated). The high overlap value may be just a random effect. Note that we consider two people who are unaffiliated to be in the same nation. Further work will try to identify why this overlap is so high.

Surprisingly, guild overlap was quite low for all values of the co-posting threshold. Guilds play an important role in the game and nearly every veteran player is part of a guild. Thus, guild member, intuitively, should have been high. One possible reason for this is the availability of other communication mechanisms. Guilds have a private chat room and have the ability to send personal messages to all other members of a guild. Thus, guild members may not need to communicate via public forum posting.

In contrast, however, results point to strong ties communicating by multiple means [6]. Assuming that guild relationships are strong, then we would expect to see communication on multiple modalities. Further work is needed to explore this.

Trading overlap was quite low as well. A key component of Game X is the necessity to trade with other players. This is the primary method of getting marks. Thus, one would expect players to trade with many others, and thus have a high overlap. The lack of such is surprising. There could be two reasons for this:

1. Players may focus on trading with guild members. Guilds

often "own" areas of the game world and set up pricing structures and trading routes. These often limit trade to members of the guild. Thus, while it is possible to trade with anyone, practically players may only trade with a limited number.

2. Geographical proximity may limit trading to a few locations. Since all movement takes some amount of turns, players may restrict themselves to small areas for trading, thus reducing the number of players they trade with.

Hostile overlap was quite minimal. This indicates players who were listed as hostile to each other did not co-post publicly. This makes sense intuitively, if we consider that co-posting as a measure of the bond between players. However, in some cases co-posting can be used to "troll" others, that is provide insulting or negative messages. These results show that while that may exist, it is does not seem to have a large impact.

Friend overlap was higher than guild, trade and hostile overlap, but experienced change as a function of the co-posting threshold, going from close to .025 to 0.15. Friend ship relationships are of relatively low number, unlike other measures. Thus, they may be more affected by the spurious edges in the co-posting network. There could also be a relationship between friendship and co-posting, indicating that friends are more likely to co-post.

The personal messaging overlap is the most interesting aspect. It is the largest by far, starting at close to 0.5 and peaking at a little higher than 0.7. It seems from this that public and private communications do interrelate.

5. CONCLUSIONS & FUTURE WORK

Social networks are important to understand for the development of social agent based model. Oftentimes, however, we are limited to generating data that is based on interaction in the public domain, such as bulletin boards, or blog posts. Public interaction may be "noisy" and may overstate or understate the strength of relationship between individuals.

In this work, we begin to explore how public and private interaction may be interrelated. Using approximately 2 years of data taken from the Massively Multiplayer Online Game Game X , we study how interactions (such as personal messaging, trading, etc) within the game were reflected in public interaction.

We conclude from this experiment that there are some strong patterns between public interaction and private interaction. In particular, if players have a co-posting relationship, there is a $> 50\%$ chance that the players are also communicating via private messaging. There is a $> 25\%$ chance that the players are of the same nation (or both unaffiliated with any nation), and there is a small chance that they are friends as well.

Some private interactions have very little probability of occurring if one is a co-poster. Players who co-post have a small probability of being hostile, trading partners, or part of the same guild.

There are several paths for future work. Currently we are only looking at the simple "co-posting" relationship. Quoting may be a stronger relationship between individuals, as it requires reading and extracting information from another's post.

So far we have not considered the content of the posts. It would be interesting to consider the emotional content of individuals as they post.

[9] suggests an information theoretic approach to examine the predictability of behavior on two sites (Epionins and Whrrl). This could be applied to our data set as well.

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