Relationships under the Microscope with Interaction-Backed Social Networks

Jeremy Blackburn and Adriana Iamnitchi
Department of Computer Science & Engineering
University of South Florida, Tampa, FL, USA
Email: jhblackb@mail.usf.edu, anda@cse.usf.edu

***Abstract*—Binary friendship declarations typical of online social networks have been shown inadequate to properly capture dynamic and meaningful social relationships between users. Interaction networks, on the other hand, rely on statistical inference and assumptions on the nature of what "friendship" means.**

This paper analyzes an *interaction-backed social network*, where an interaction network and a declared social network coexist without constraining each other. We show quantitatively how many interactions take place within a declared relationship, but also that there are interactions between users without a declared relationship. By measuring interactions between declared and non-declared pairs of users, we can discover how levels of interaction wax and wane, and how attention is diverted from existing relationships to forming new ones. Our quantitative analysis can also serve scientists to create interaction workloads from declared social networks or infer social networks from interaction traces.

I. Introduction

The abundance of social information exposed by online social networks (OSNs) and Web 2.0 applications has enabled the mining of declared social relationships to unprecedented degree. Unfortunately, the ease of relationship creation and hidden incentives to declare many "friends" lead to significant concerns about how findings from OSNs might transfer to real world situations [1]. Moreover, declaration-based OSNs provide little insight into interactions between pairs *without* a declared relationship.

An alternative data source for exploring relationships are interaction networks. For example, data traces from cellular networks [2] have been used as empirical evidence for theories on tie strength, and traces of email chain letters have shown the existence of small world effects in digital communication [3]. However, although interaction-based networks alleviate the questions of relationship meaning, they fail to capture the significance of *explicitly declared* relationships. Instead, researchers must rely on statistical inference and make assumptions on the correlation between interactions and relationships.

One way to mitigate these concerns is to examine *interaction-backed* OSNs, which we define as Internet-mediated communities where declared relationships and interactions can be independent. (Facebook, for example, is not interaction-backed, because two unconnected users cannot interact within the application.) Interaction-backed OSNs more accurately portray real-world relationships where relationships form over time due to extended, meaningful contact between individuals and interactions are possible without the responsibility of a formally declared relationship. Interaction-backed OSNs thus bridge the gap between interactions and explicitly declared relationships.

In this paper, we study such an interaction-backed OSN formed of online game players. Gamers relationships are compelling for several reasons. First, gaming is a very popular activity, with multiplayer games breaking historical records for entertainment sales [4], pushing cutting edge consumer hardware [5], and attracting hundreds of thousands of viewers in live events and millions of dollars in prize money [6]. Second, in-game interactions are considered to mirror real-world interactions [7]. And finally, gaming platforms are built to support gaming interactions and often have a separate, optional, declarative OSN. Gaming interactions do not require the functionality of the OSN, but the OSN facilitates out-of-game interactions (such as chat, announcements, etc).

For these reasons, we analyze a 10-month data trace from a community-owned and operated game server for one of the world's most popular multiplayer games and the corresponding set of players' declared friendships. We analyze the correlation between the two graphs: the in-game interaction network and the declarative OSN. Our analysis captures quantified differences between interactivity along declared relationships in comparison to undeclared relationships.

The remainder of the paper is organized as follows. Section II describes our dataset. The results of our analysis are presented inSection III. Related work is discussed in Section IV. Finally, we conclude in Section V.

II. Dataset

Our dataset consists of in-game events from a popular *Team Fortress 2* (TF2) server and of the corresponding declared social ties in *Steam Community*, an online social network of gamers maintained by Steam, the dominant digital game distribution platform on PCs. We crawled the Steam Community to collect the profiles of the players in our logs [8].

A. Team Fortress 2

TF2 is a team- and class-based, objective-oriented first person shooter game released in 2007. Game sessions in TF2 are hosted by individual servers, most often owned and operated by independent gaming communities. Gameplay pits two teams, Red and Blue, against each other on a variety of maps. Some maps are symetrical, with both Red and Blue attempting to complete the same objective, and others are asymmetrical, with Blue attacking and Red defending the objective.

Once players join a game they must choose a team. After choosing a team, players choose to play as one of 9 classes. Players are allowed to switch classes at any point of the game, and while certain team compositions might be more or less viable, players can choose a class independent of the choices made by the rest of their team. A regular stream of free content updates (335 as of January 2013 [9]) has kept TF2 popular since its release.

B. The Server

We obtained just over 10 months of gameplay traces (from April 1 to February 3, 2012) from "The Slaughterhouse" (SH), one of several TF2 servers operated by the "Brotherhood of Slaughter" (BoS) gaming community. The server, located in Los Angeles, California, hosts up to 30 players simultaneously, costs approximately $250.00 a month to operate, and is completely funded by donations from the BoS community.

SH has been customized with a variety settings. Of note is the `alltalk` setting, which broadcasts all voice communications to both teams, chosen by the BoS server administrators to foster a fun, social atmosphere, as opposed to a purely competitive environment. As voice communication in games like TF2 both influences, and is influenced by, gameplay [10], a server like SH can produce an intense social gaming experience when filled with a talkative crowd.

The logs contain information such as gameplay events, in-game team and server-wide text chat, and map nomination and votes. We extracted 12,621,543 gameplay events. Such events include, for example, one or more players capturing territory together, or two players on the same team working together to "kill" a player on the opposing team.

From the extracted events, we created an undirected *interaction graph* where an edge exists between two players if there was at least one event that involved both players. Each edge is annotated with a time series corresponding to the times of the extracted event between the players. In total there were 18,743,644 pairwise interactions, i.e., the sum of the length of all edges' annotated time series.

C. The Steam Community

Steam Community is an OSN of Steam users, i.e., people who buy and play games on Steam, a digital distribution platform. A Steam profile includes a nickname, a privacy setting (public, private, or friends only), set of friends (identified by SteamIDs), group memberships, list of games owned, gameplay statistics for the past two weeks, a user-selected geographical location, albums of posted screenshots and videos, and even a portfolio of user-created modifications to games. Ties in Steam Community can be declared totally independent of gaming interactions: they are not required to play games together, but they provide a persistent, game-independent contact channel.

Table I presents the size of our dataset. There are 33,546 players on the server who are part of the Steam Community OSN, involved in over 1 million relationships. Of them, 22,099 have 50,522 friendships where both friends played on the server. Of these, 7,701 friends interacted on the server during our observations, forming 13,270 interactive pairs.

Graph	*# Players*	*# Edges*
Steam Friends	33,546 (620,789 non-players)	1,038,133
Server Friends	22,099	50,522
Interaction	33,546	1,768,528
Interacting Friends	7,501	13,270

TABLE I. DETAILS OF OUR DATASET.

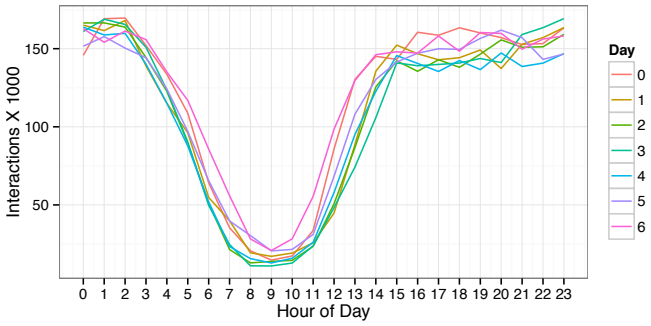

Fig. 1. Number of interactions per-hour, per-day of the week (from Sunday).

III. Data Analysis: What's in a Relationship

A. General Server Characterization

We begin with a general characterization of the SH community. Like any community, the social environment of a virtual community helps shape the interactions that occur.

Fig. 1 shows that the community is quite active on any given day of the week. On all days, activity levels are the highest in the afternoon, and begin to fall off around midnight Pacific Time. We note that Saturday, a "pure" weekend day, has a relatively higher level of activity during normal working hours, with Sunday having the second highest level.

This sustained activity during non-working hours drastically differentiates this dataset from interactions in declarative OSNs such as Facebook. Gaming is a leisure activity that requires adequate, and often specialized, hardware, and more importantly, significant focus and concentration. Unlike other online social activities such as instant messaging or browsing Facebook profiles, gaming sessions are continuous and preclude multitasking. Hence, activity levels correlate to the times of day that gamers are not encumbered with the distractions of work or school.

B. Declared Relationships

Fig. 2 plots the degree distributions of the players on the server. The Steam Community degree distribution is based off the entire friends list of players, while the Server Friends degree distribution is based off the subset of a player's friends that also played on the server. The interaction distribution portrays the number of interaction partners each player had.

From the plot we first observe that Steam Friends distribution of players is the same as the degree distribution of Steam Community as a whole observed in [8]. We also see that players have many more interaction partners than they do declared friends, and tend to have fewer friends that play on the server than they do overall. Both of these results mirror real-life experiences that are not captured by interaction graphs or declarative OSNs alone: not everyone we interact with

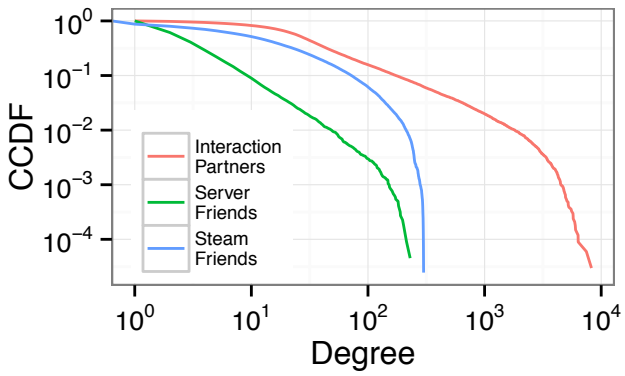

Fig. 2. Degree distributions for SH players.

becomes a friend, and we interact with a subset of our friends depending on the venue.

What is not necessarily intuitive is the shape of the server friends curve. While we might expect the server friends curve to have the same shape (yet shifted) as the Steam friends curve, this is not the case. Instead, the shape mimics that of the interaction partners curve, giving us our first indication that interaction and declared friendships are related.

C. Interactions and Declarations

Having established the activity level of the server community and the engagement of its players in the online social network of Steam, we next examine the relationship between the two. Ultimately, we find that declared pairs have *many* more interactions than undeclared pairs.

There is a striking difference between the interaction patterns of declared pairs and non-declared pairs of players, lending credence to the strength of declared relationships in an interaction-backed OSN like Steam Community. Fig. 3 plots the average number of events per hour of the week for interacting pairs, differentiated by the existence of a declared relationship, across the entire span of our log files. Friends averaged several orders of magnitude more interactions than pairs without a declared friendship.

One unexpected finding is that the peaks in Fig. 3 for declared pairs are during the week. This is in contrast to Fig. 1 which shows higher levels of activity during the weekends. One possible explanation for this difference is that the server population skews towards "regulars" during the week and includes more "randoms" during the weekends. This hypothesis fits well with the concept of an interaction-backed OSN: regulars are more likely to interact more, and their interactions are more likely to spawn declared relationships in the OSN.

IV. Related Work

Wilson et al. [1] questioned the meaning of friendships in declared OSNs by examining interactions between users on Facebook. They define an interaction graph to be a subset of the Facebook social graph (since Facebook interactions are limited to individuals with declared friendship) where the two end points had n interactions over a time interval t, and show that users only interacted with a small subset of their friends, that interaction degree is not correlated with social degree, and that small-world clustering decreased as the interaction graph becomes more restrictive. One aspect they leave open for future work is the construction of interaction graphs that are *not* a strict subset of the social graph. The work in this paper is a first step towards filling that gap since our interactions exist in a separate, although related, context than the OSN they back.

Xu et al. [11] interviewed 14 *Halo 3* players to study the meaning of relationships within an online gaming context. They found evidence of in-game relationships supported by real-world relationships, triadic closure of relationships making use of both real and virtual relationships as a bridge, and in-game interactions strengthening ties in the real world. Mason and Clauset [12] investigated the behavior of *Halo: Reach* players combining gameplay summaries with pyschometrics and a social network constructed from survey data. They find that gamers preferred to play with friends, and that the duration of time played together was a useful predictor for a friendship.

A major difference with our work is the use of surveys vs. an OSN as ground truth for a friendship existing. Considered together, our work and theirs, particularly Mason and Clauset's results that playing together is a useful proxy for friendship and our results that declared friends have orders of magnitude more interactions than non-declared friends can be taken as evidence that declared relationships in gaming related OSNs might very well represent real "friendships."

There is an additional subtle, yet important difference between these works though: the mechanism for finding play partners. In Halo, the primary mechanism is a skill-based matchmaking service [13], which places groups of players of similar skill into a peer-to-peer gaming session. To play with the same teammates, players must explicitly choose to "party up", and anecdotal evidence suggests that most players back out of the party up option after games with random players. In contrast, the mechanism in TF2 relies on players explicitly choosing a particular community owned and operated server, each with their own unique personalities and atmospheres, for play. This makes the selection of a virtual environment an analogue to the selection of a real world environment. For example, the frequenting of a particular pool hall, chosen not just for the competition but also for the camaraderie exhibited by the community. This easily accessible metaphor hints at the applicability of our results to real world scenarios.

Our previous works were the earliest studies of gamers in the Steam Community OSN [14], [8]. The dataset we analyzed comprised over 10 million friends lists and a small sample of the log files used in this paper. The work included a cursory investigation of gamers activity levels and socio-gaming characteristics, however, the focus was on the position of unethical actors (cheaters) in a planetary scale social network. In addition to the above, we proposed a distributed social infrastructure in [15]. We again used a small sample of the logs used in this work to build a proof-of-concept social sensor which produced a weighted social graph based on player interactions.

This paper compliments our previous work by providing a more intimate view of declared relationships. Our new findings indicate a high degree of correlation between declared relationships and interactions. This strengthens the hypothesis

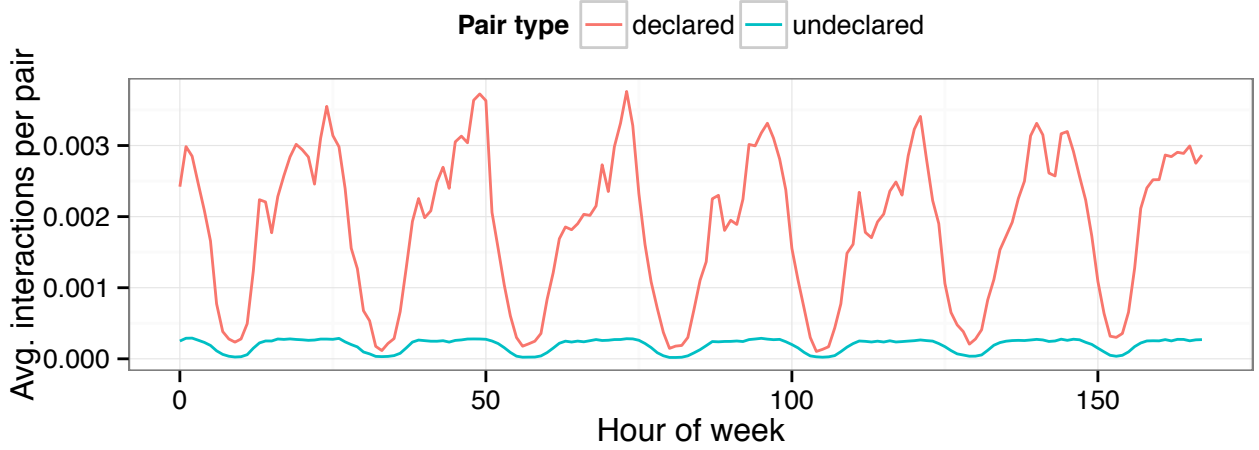

Fig. 3. The average number of interactions per hour of the week for interacting pairs. Hour 0 is Sunday midnight (0:00)

that declared relationships are meaningful enough to allow for the diffusion of innovation, and suggests a possible mapping to interaction-based contagion models [16].

V. Summary

While declarative OSNs have been the focal point of a new understanding of human relations, concerns about the validity of the relationships they describe remain. The implications for researchers is that while declarative OSNs provide a model for human relationships, they might fail to provide a full view of what differentiates a friend from a non-friend.

This paper explored the link between interactions and declared friendships of gamers in the interaction-backed OSN Steam Community. From detailed gameplay logs of an active community-owned and operated server, we examined the interaction patterns of both players with a declared relationship and those without one. We discovered that player pairs with a declared relationship had orders of magnitude more interactions than those without a declared relationship, even though there were multiple orders of magnitude more interactions in total between non-declared pairs than declared pairs.

This suggests a new direction for researchers interested in moving past the simple relationships exposed by OSNs like Facebook. Instead of examining services whose utility is derived solely from declared ties in the OSN, thus obscuring interactions between non-friends, a more enlightening approach is to seek out and investigate interaction-backed OSNs. Studies of interaction-backed OSNs could elucidate, for example, the interactions preceding the creation of a friendship, or how attention is diverted from existing friends to a new contact prior to the next contact being declared a friend. In other words, not only what it means to be friends, but, what it means to *not* be friends.

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