Understanding the Social Network in Cooperative Games

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Abstract—Nowadays, Online Social Network (OSN) such as Facebook has become a prominent communication tool which serves hundreds of millions of users. However, the OSN is not the only method that people can communicate with each other on the Internet. In this paper, we adopt the social network analysis approach partially and apply it to online cooperative games studies with some mapping strategy. To achieve that, we present a previous case study which investigated social network existed in Defense of the Ancients (DotA) to show how social network works in computer games. Afterwards we discuss the implication and limitation of the study.

Keywords—Online Social Network, Social Network Analysis, online cooperative games.

I. INTRODUCTION

A. Background Statement

Recent decade has witnessed the development of virtual communication which based on the proliferation of the Internet technology. Thus, the emergence of substantial virtual communities such as Facebook and online social games become an inevitable tendency. In this paper, we aim to address the social network in computer games, that is, in online cooperative games where social element exerts positive influence on players’ performance.

In general, there are two things to determine whether a computer game is successful, one factor is design of the interface and another is how each user can communicate with other players effectively. Consequently, to evaluate the success of a game has been addressed in many Human-Computer interaction works [1] in a sense. More specifically, game evaluation methods integrate many HCI methods to test playability of the game and engagement of the player, which draws owner of game company’s attentions. For instance, according to Panayiotis and Chee [2], substantial works have been done in this area such as 3D graphics and 3D sound, visual and audio elements of computer games etc to enhance engagement and immersion in game playing. Nowadays, several games have successfully achieved these goals such as Word of Warcraft (WoW), Leaf 4 Dead and Defense of the Ancient (DotA).

In this paper, we adopted a social network analysis (SNA) standpoint, which focusing on the relations and structures, to cast new light onto user interaction in virtual works. These kinds of social networks exist in online social games rather than conventional games. Comparison between conventional single games and multiplayer online cooperative games [3]: For conventional applications, user who want to join in communities must use third party tools which not only require extra effort, but also takes discussion out of the context of the application. By contrast, multiplayer games have integrated the natural community with the applications successfully. Therefore, conventional games seem to be out of date because an increasing number of players put more weight on communication in games in order to achieve the goal more efficiently instead of playing alone.

B. Why choosing Online Cooperative Games

Recent decades have witnessed the prosperity of cooperative games since electronic sports have been treated as a formal sport around the globe.

In game theory, a cooperative game is a game where groups of players may enforce cooperative behavior, hence the game is a competition between coalitions of players, rather than between individual players. As a result, there must be social element in cooperative game which makes this competition more attractive.

Generally speaking, people play games for these four reasons[4]: (1) hard fun: people are motivated by achievement, (2) easy fun: people are motivated by exploration, (3) altered states: people are motivated by abundant rewards of finishing the mission, (4) social needs: people are motivated by the competition of the cooperative games or just want to play with friends. Absolutely, the conventional games fail to provide fun which is belong to the forth point.

A survey conducted by N. Yee[5] demonstrated that 55% of total 6-16 kids preferred cooperative game. Cooperative games encourage participation and collaboration, the goal of the game is not to win as a player but as a team of players[6]. For the purpose of that, G. Wadley et al[7] mentioned that a community or guild is indispensable for a cooperate or online game in order to form a team and best accomplished a mission. Therefore, some online games offer a chat room or forums where players can communicate with each other. Each guild often owns a leader and several guilds could team up in a battle. This involves a complicated leader-subordinate and leader-leader relationship.

Online cooperative games such as League of Legends (LoL) and Defense of the Ancients (DotA) attract tens of
millions of gamers each year. The game is fragmented into substantial non-communicating instances (matches), which involve ten players in any instance of the game at any one time. Players can have access to partners or even opponents for a game instance through the use of community web sites such as Facebook and online chat tools such as MSN. Also, the game itself provides gaming community or platform for players which contain the services that matchmaker the players to a game instance. Unlike many online social network, one interesting feature of these sorts of gaming communities is it not only provide friend list for players but also adversarial lists as useful relationships. That may because some players want to find the same opponents in several games for revenge or other reasons.

In reality, it may be difficult to obtain a clear social network from an online cooperative game because data we see from gaming community may be modified for keeping this community with great profits and prosocial profile. As a result, the analysis of online cooperative games has to choose the extraction rule, which used to extract graph links from play relationships recorded in the logs of completed and ongoing game instances. For instance, extracting social network graph from online cooperative games through the simple rule of forming a link between gamers that have played at least once together.

C. Social Network Analysis

The concept of Social network analysis (SNA) has received increasing attention in the past decades. Through the analysis of the social network people have access to people's behaviors and predict their behaviors. More specifically, SNA is the mapping and measuring of relationships and structures between actors such as people, groups, organizations, etc [8]. The application of SNA can be used in both virtual and real community.

For real-world community, to investigate the citation interaction of the members within interdisciplinary research groups, White et al. [9] have successfully applied statistical methods for SNA such as Quadratic Assignment Procedure (QAP) [10] into their study. Finally, their result depicted it was intellectual ties rather than social ties that determined the citation interaction.

SNA was also used in basketball area. Vaz de Melo [11] put forward a matrix which was a complex network approach to predict the performance of basketball teams. In that paper, a network-based ranking of players had been come up with to replace current statistics such as assists and points.

In social-oriented interaction in virtual communities, we take Ducheneaut's work [12] for example: it attempted to test the sociability of players in Star Wars Galaxies and its results were rather insightful. In addition, it highlighted some game design aspects, which could be applied to different styles of player interaction. Additionally, some work aimed to predict people’s behaviors through analyzing their online behavior in blogs [13].

Except for gaming, SNA plays a key role in terms of analyzing study behavior as well. A series studies have been done [14] in an attempt to form a framework for analyzing collaborative learning based on computer support and proposed the methodology in the evaluation framework of e-learning.

In the last few years, SNA was applied to study larger scale online networks [15], [16], [17]. According to related work, we can use SNA to analyze user interaction through relational and structural perspectives in various settings such as online and offline. Consequently, this strategy can undoubtedly suggest online user interactions in cooperative game.

D. Related Work

In general, analyzing the social network in cooperative game has enjoyed an increasing popularity in recent years since more and more people engaging in it. Within this area, a number of studies divided players into different classes by applying network metrics. Kriman and Lawson [18] extracted network from a cooperative game by creating relationships between players that exchanged information in the game. Players were divided into three types (Hardcore, Casual and Peripheral) based on their activity within the network. Finally, they found the play style of player can not only be identified by their personal preference, but also the number of communication in the game.

On the other side, Rocha addressed the importance of social network in cooperative game by coming up with six cooperative game design patterns in his work [19]:

**Complementarity:** It implies that players play different character roles which have different abilities in cooperative games (there is some complementarity between the characters that players control) to complement others' activities within the game.

**Synergies between ability:** Allows one character type to assist or change the abilities of another, that is, through applying the abilities of two players together, the effect of every ability will be enforced.

**Abilities that can only be used on another:** For example: Medic can heal other players. This partly because the purpose of these abilities to encourage cooperation between players.

**Shared goals:** A group of players will have one non-exclusive goal, which can force players to work together.

**Synergies between goals:** It is a pattern that forces players to co-operate together through synchronized goals. To be more exact, players must assist teammates to finish their missions if they want to finish the mission.

**Special rules:** denote rules that are used to enforce cooperation within teams. For instance, shooting teammates of your team in FPS games will receive punishment.

However, these patterns have overlapped to each other in a sense and some of new patterns need to be discovered.
Another work [20] focused on investigating the differences between networks formed based on different types of interaction in online cooperative game World of Warcraft. In this study, the author investigated 76 players that formed a single guild and then extracted networks by creating links between players. In addition, Different kinds of interaction were classified into seven categories such as asking for help and coordination which based on the purpose of the interaction. Through the combination of qualitative and quantitative analysis of the results, the author not only cast new light onto the network structure but also provided qualitative evidence the nature of interactions embedded within the networks. Finally the author found that different types of interaction lead to different network.

Nonetheless, limitations were existed in this study. Firstly, the investigation only covered small number of players (76), which lacked of representativeness. Secondly, players were formed to a single guild rather than multiple groups, which could compare the same type of interaction in different groups.

II. CASE STUDY

A. General Introduction of Defense of the Ancient

To test the importance of social network in computer games, we analyze an existing study [21] which used a multiplayer online battle arena (MOBA) game named Defense of the Ancients (DotA) to illustrate how the relationships of players in games can enhance the performance.

DotA is a sort of MOBA game which is popular all around the world. It is a competition item in many tournaments such as the World Cyber Games (WCG) and the Electronic Sports World Cup (ESWC) which attract countless players and game-watchers around the globe. It is a 5-against-5 player game, which means there are two contesting teams in one match and each team consists of 5 players. Each player in game controls a character so called “the hero”. The purpose of each team is to conquest the base of the other team. To win the match, players in one team should communicate and cooperate with teammate effectively. More specifically, formulating strategies of your team operation to the management of resources and creation of helper troops is an essential part for a match. On the other side, trying to figure out the strategy enemy use is important as well.

There are vast of DotA communities around the world, which provide platforms for players a battle field to show themselves. Furthermore, some of communities maintain lists of tournaments and results, and publish information such as resulting player rankings through common websites.

B. Two Datasets

In this study, two sets of data were collected from two DotA communities, Dota-League and DotAlicious over several years. The paper introduced the concept of played match which illustrates the match that had been played only for matches with correct start and end timestamps in order to sanitize the dataset. More specifically, the DotA-League dataset composed by 1,470,786 played matches which played between July 2006 and July 2011. Besides, for DotAlicious, the dataset consisted of 617,069 played matches.

C. Mapping the Datasets
Generally speaking, the common way to analyze social network is to model a dataset as a graph. In a mapping, each entity is mapped to a node while relations between entities are mapped to links. In this study, each player in the dataset was always mapped to node and nodes without adjacent would be discarded from extracted graph. Here the concept of threshold \((n)\) was applied to investigate how a specific mapping or threshold affected the resulting graph. The study explored six different strategies according to different gaming relationship between two players:

- **SM**: The number of times two players are in the Same Match is greater than \(n\).
- **SS**: The number of matches played on the Same Side is greater than \(n\).
- **OS**: The number of matches played on the Opposing Sides is greater than \(n\).
- **ML**: The number of Matches played and Lost together is greater than \(n\).
- **MW**: The number of Matches played and Won together is greater than \(n\).
- **PP**: In this mapping, a directed link exists from player A to B if player A has played at least \(n\)% of all his/her matches with player B.

Afterwards, by using different mapping strategies, different graphs will be got to demonstrate whether the relationship in each mapping resulted in different graph structures.

### D. Spectral Metric

In this research, the author introduced a spectral metric (see Table 1) to show the network extracted from different mapping strategies. These metrics could reflect social relations in two gaming communities. The metrics included in Table 1 will be explained in the following.

**Size(s) of the connected component(s)** \((N, L)\): This indicates how many fellow players a single player can reach in the network.

**Link density** \((d)\): Indicates how densely connected the network is.

**Algebraic connectivity**: It is a spectral graph metric which shows how well connected a graph is.

**Average hop count** \((\bar{h})\): This metric measures how many hops players are removed from each other on average.

**Diameter** \((D)\): It represents the longest shortest path in terms of hops in the network.

**Average clustering coefficient** \((\bar{C})\): It indicates how many neighbors of a node are also neighbors of each other.

**Betweenness centrality** \((B)\): It is a measure of a node's centrality in a network equal to the number of shortest paths from all vertices to all others that pass through that node.

**Assortativity Coefficient** \((\rho)\): Used to measures to what extent nodes link to other nodes with similar degrees.

The more specific explanation of each element in the table above refers to [22], [23]

### E. Analyzing the Graphs

In this section, we present part of existing analysis and findings of this study and come up with new conclusion. More specifically, we divide analysis into following three factors:

1. **Network sizes**: In general, from table 1, although the number of played matches in it is only half of that in Dota-League, DotAlicious dataset includes more links while both Dota-league and DotAlicious own approximately the same nodes. Furthermore, the dataset of DotAlicious is denser according to the fifth and sixth row. In addition, players in DotaAlicious tend to be more likely to play in the same match and same side through nodes of SM, SS and PP mapping. This can indicate that playing together can help to form a stronger social bond than playing against each other. Additionally, the ML and MW mapping for both communities almost equal to each other, which indicates both communities have a matching mechanism that allocates teams with almost the same strength in one match.

   From Figure 1 (right) we can see that players in DotAlicious prefer to play with friends and win together whereas players in Dota-League (left) have a larger chance to play in opposite side. Additionally, the line of MW for DotAlicious tends to become stable at the end which depicts that win together can form a solid and long-lasting friendship and solid social relationship can enhance the performance of players. However for Dota-League (left), there is a drastic decrease occurs both in MW and ML because players fail to
choose which side they play before each played match under Dota-League matching mechanism. What player can do is just to join the waiting queue and assign to one side randomly. Arguably, there is an interesting finding that the number of ML and MW in Dota-league almost the same, which reveals a 50-50 win ratio for this DotA community.

Evidently, by using different mapping strategies we can get different graphs illustrating with almost the same conclusion. As can be observed in Figure 2, the PP mapping can also reveal a difference between two SM mappings. Although both communities have a relatively high number of nodes for SM mapping, only players in DotAlicious play a high percentage of their matches with a selected group of players. Also, PP mapping indicates all players have a win ratio of 50%.

(2) Social Network Structure: The statistics in the lower half of Table 1 provide an insight into the social structure of the network. Watt and Strogatz [24] use small-world property to demonstrate the network with a low average hop count and high clustering coefficient. To be more exact, the relatively high clustering coefficient depicts that a friend of your friend is likely to also be your friend. According to Table 1, the clustering coefficient of players that played in the same match is approximately 0.4 (0.37 for Dota-League and 0.43 for DotaAlicious), which elucidates that players you play with are also likely to play among each other. Arguably, a law can be found that higher clustering coefficient leads to higher MW whereas lower clustering coefficient causes higher ML when comparing the statistics of two communities, which indicates that winning together strengthens relations and losing matches results in a slightly weaker relation. Therefore, social network does exist in cooperative games and can affects player's performance.

Nevertheless, foe relations are indispensable for a competitive game which can be studied via OS and SS mappings. As we can see from Table 1, the OS mapping creates a low clustering coefficient compared to SS mapping. Intuitively, this because although a friend of your friend is also a friend of yours, an enemy of your enemy is also your friend. However, the lower clustering coefficient cannot be explained by other properties such as density because indeed link density in OS mapping is higher than in SS graph.

While the Dota-League dataset demonstrates no large strongly connected component (N_{L}), a largest connected component of 3,000 nodes is depicted in DotaAlicious dataset. Nonetheless, the largest strongly connected component extracted from the DotAlicious dataset is poorly connect because its average hop count is 18.45.

(3) Impact of the Mapping Threshold: To illustrate Figure 3, where plots from left to right show the decline of threshold. With the decrease of the threshold, a few connected small clusters in the left-most image grow into a large connected component. In real situation, players first organize in smaller clusters before these smaller clusters all connect.

Figure 4 also depicts this sort of finding, which is as the growth of threshold, the dominance of the largest component diminishes and quickly falls apart in many small components. The peak value of number of component is roughly at a threshold of 28.

Figure 5 illustrates the number of strongly connected components in the directed graphs extracted from PP mapping. Absolutely, the number of strongly connected components peaks higher in the network extracted from DotAlicious dataset than Dota-League.

Additionally, the betweenness centrality (B) and coreness (c) can provide clues as to whether a graph contains significant nodes. To illustrate the function of betweenness centrality more specifically, for the graphs constructed with the lower thresholds, it represents some players play an increasingly prominent role in facilitating short paths.

Finally, this paper proposed a graph-inspired matchmaking algorithm which led to much stronger social ties than random matchmaking system. More specifically, this algorithm could serve as an example for system designers on how to strengthen or leverage the social ties between players to increase their experience and to attract more players. For further detail of this proposal, we refer to [21].

III. DISCUSSION
A. General Discussion

In this paper, we aim to understand the social network in computer games. To achieve this goal, we first presented several works in analyzing the social network in games with
social network analysis. Subsequently, a specific case study was elucidated to prove the social network in games. Through the analysis of this particular case study we conclude that social interaction is essential in computer games because it can not only establish a friendly environment but also enhance the performance of players.

Except for the analyses above, we came up with several new findings through analyzing table and figures above:

(1) Concluded from Table 1, players in DotAlicious enjoy a solid social relationship than that of Dota-League although the number of played matches in DotAlicious is smaller than Dota-League in following factors: Firstly, the number of nodes in SS, ML, MW and PP mappings in DotAlicious were all greater than that in Dota-League. Secondly, the higher average clustering coefficients for SM, SS, ML and MW mappings in DotAlicious and lower average hop count elucidated this point.

(2) As we mentioned above, since the game mechanism in Dota-League failed to allow players to choose which side they played, players can only joining the waiting queue and wait for allocating. As a result, social interaction was weak in terms of Dota-League whereas in DotAlicious players were more likely to play with friends according to SS and PP mappings. However, the win rate of players in DotAlicious was a little bit lower than that in Dota-League referring to MW mapping. That may because players on both sides in DotAlicious were likely to be friend with each other, which means that social relationship existed in both sides. As a result, no matter which side won could both illustrated the importance of social relations in games.

(3) From Figure 2 and 3 we can found that the value of threshold exerted profound influence on social network. More specifically, the small size of social community was first established with the increase of threshold and the number of it increased drastically and peaked at the threshold value of approximately 28. Afterwards, small size of communities began to connect together and formed larger communities according to Figure 2. Besides, number of connected component began to decline slightly since number of small size communities merged into larger one. Then with the growth of threshold, some connections between communities disappeared and finally some nodes vanished in accordance with Figure 2 and 3 and only smaller number of links still existed. This implies long-term social relationship rarely survives in computer games because (i) it eventually a virtual community that not all of players can always stay online and play with their virtual friends without caring about their real life. (ii) Links between nodes may disappear when players in the same team losing the match all the time or contradictions emerge. Nevertheless, it does exist and affect the performance of the games.

(4) Through the concept of betweenness centrality we know that there are several nodes in each mapping strategy locate in the centre of the community and many links go through it. We can elucidate this situation in real life that (i) there are some players with excellent gaming skills which are called “super player”. It is common sense of people that players tend to establish a relationship with these “super player” for the purpose of winning the match. (ii) These nodes can also represent the active players who are fond of joining different communities and making friends. Therefore, these players are likely to become the “bridge” between different communities.

(5) It is interesting to find that we can see from all graphs (except for Figure 2), the curves for ML and MW are almost overlapping each other, which indicates no matter players play with friends or by themselves, the win ratio always be approximately 50%. In reality, both Dota-League and DotAlicious communities can help players to find opponents with the same level.

(6) Threshold plays a significant role in determining the structure of mapping. More specifically, even slight variations in the threshold value can completely change the graph metrics for the largest component, and this also for lower values of the threshold.

On balance, through analyzing the relative work and case study, we have a general picture of the social network in online cooperative games. If we go further to mining the dataset we get from Dota-League and DotAlicious communities, we may find substantial interesting conclusions as listed above. Additionally, we can use findings we get to propose an algorithm to enhance the ability of matchmaking system.

B. Limitation of the Study and Future Work
Although the paper we studied has elucidated the play relationships in online social games specifically, some strategies can be applied to make the investigation more accurate and convictive.

1. In this paper, all mapping strategies were compared and illustrated under the same value of threshold (see Table 1). The authors failed to measure the social network under multi-threshold condition. To extend this, we can also list a table to compare the same mapping with multi-thresholds.

2. New mapping strategies can be applied except the existing six strategies to figure out more play relationships.

3. The choices of collected datasets should be more extensive such as game communities on a global scale to investigate whether this sort of play relationship can vary from different cultural backgrounds.

Undoubtedly, investigating play relationships in computer games is an interesting and promising research area. Since games have become a global language following arts and sports, it can be a bridge to fill the gap between different cultures and backgrounds.

IV. CONCLUSION

In this paper, we aim to understand the social relationship in computer games. To achieve that, we first introduced the background of this area and then had access to the SNA method, which applied extensively to analyze the social network in both virtual and real communities. Afterwards, through the introduction of related works, we knew the importance of social interaction in computer games. Subsequently, a specific case study was presented to illustrate the social network in online cooperative games, which paves the way for the future study. Afterwards, some strategies such as explore more communities and come up with more mapping strategies were put forward to study the social components in games more accurate.

REFERENCES


Fig. 5: Number of strongly connected components with PP mapping for Dota-League (left) and DotAlicious (right)


