Identifying Spreaders of Malicious Behaviors in Online Games

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ABSTRACT
Massively multiplayer online role-playing games (MMORPGs) simulate the real world and require highly complex user interaction. Many human behaviors can be observed in MMORPGs, such as social interactions, economic behaviors, and malicious behaviors. In this study, we primarily focus on malicious behavior, especially cheating using game bots. Bots can be diffused on the social network in an epidemic style. When bots diffuse on the social network, a user's influence on the diffusion process varies owing to different characteristics and network positions. We aim to identify the influentials in the game world and investigate how they differ from normal users. Identifying the influentials in the diffusion of malicious behaviors will enable the game company to act proactively and preventively towards malicious users such as game bot users.

Categories and Subject Descriptors
J.4 [**Computer Applications**]: Social and behavioral sciences; K.8.0 [**Personal Computing**]: General---Games

General Terms
Management, Measurement, Security, Human Factors, Verification.

Keywords
User Influence, Online Social Network, Game Bot, Online Game.

1. INTRODUCTION
MMORPGs are very similar to the real world and require complex user interaction. Many human behaviors, such as social, economic, and malicious behaviors, can be observed in MMORPGs. Players take pre-scheduled courses to achieve high-level characters and become rich in cyber-assets. These courses require lengthy and repetitive play. To circumvent this and acquire more cyber-assets in a shorter period, users have started to cheat, especially by using game bots. Since bot players' activities and the extraordinary level-up of friends are noticeable in the game world, normal users are exposed to more game bots when their friends use bots. Therefore, game bots can be diffused on the social network in an epidemic style [1, 2]. Most of game companies ban bot users' accounts when they repeatedly use game bots. Banning accounts often cause a legal issue between the user and the game company and the detection has low effectiveness in preventing bot use. By targeting influential users,

a game company is able to minimize the compliance risk while maximizing the banning effect. In this study, we will identify the influentials who diffuse the malicious behavior in MMORPGs. We expect this study to usher in a new era of preventive strategies against game bots.

2. RESULTS
In this study, we aim to test following hypotheses that some users are more influential than others and the number of friends a user has does not necessarily equate to a high level of influence on others. Previous works on user influence showed that the above hypothesis is supported in product adoption, information diffusion, and disease outbreaks [3, 4]. Understanding of the different roles of users in online games is important for game marketing, game design, and a security strategy.

We used the anonymized database that includes the bot detection records and users interaction records between December 21, 2011, and March 21, 2012 from AION, a prominent MMORPG developed by NCSoft. 94,864 characters played the game during that period and 54,989 characters were on the friend network. The bot detection code was recorded to 14,327 characters. We considered users whose the numbers of bot records exceed 1 as bot users. We define spreader as the initial character who use the game bot before his/her friends start to use it. Among 8,332 bot characters, 4,879 characters were estimated as spreaders and 5,851 characters were observed as imitators. To confirm the existence of super-spreaders, we examine the induced sub-graph of the friendship network, which includes spreaders and imitators. The induced sub-graph has a large variance with exponential distribution as shown in Figure 1. We found that MMORPGs contain super spreaders similar to those in an epidemic.
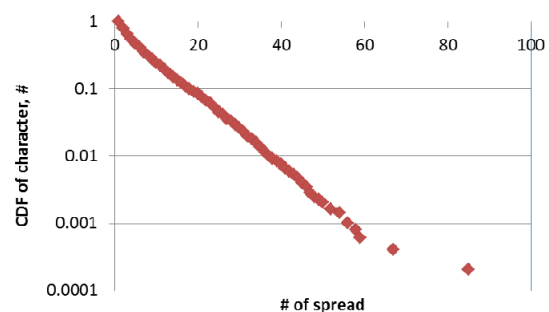

Figure 1. The cumulative distribution function of the number of spread.

We compared a spreader's rank in terms of the number of friends and the number of spread as shown in Table 1. Overall, the rank of the spread is proportional to the rank of the number of friends. That is, the more friends a character has the more chances the character has to spread. However, this is not a necessary condition for super-spreaders since top 1% and 10% of spreaders have correlation less than 0.5.

Table 1. Rank correlation coefficient

	Top 1%	Top 10%	Total
Friend, # vs spread,#	0.411	0.426	0.680

Then, whom should we target to prevent the spread of bot use effectively? To answer the question, we investigate users' friends, and users' bot usage patterns and play patterns. As we can see in Table 2, heavy users tend to have more spread toward other friends. Half of the spreaders have at least 33% of their friends using bots. The adoption of the game bot exhibits the positive network effects. This indicates the existence of the contagion.

Table 2. Game activities according to user classes

User types		Spread, #	Bot use, #	Bot friends, # /Friend, #
Spreader	Top 1%	10	43	0.45
	Top 10%	6	24	0.39
	Total	4	4	0.33
Total users		0	0	0.13

We measured a user's game involvement by estimating the number of connections and playtime per a user. In addition, character level is another important discriminator to explain a user's game involvement level. As a user puts in more effort, the character achieves higher levels. Table 3 shows that, spreaders showed high involvement in terms of connection time and play time compared to top 10% of friend holders. However, the character level is not a significant measure for identifying spreaders. Furthermore, we analyzed the in-game characteristics of spreaders including character gender and job. Spreaders do not show any meaningful difference in terms of in-game characteristics such as character gender and character job. Finally, we investigate the user interaction between spreader vs. imitators and spreader vs. non-imitator. In our case, imitators are those who adopt the game bot after their friends use them. This analysis will reveal whether or not user interaction affects the spread. In general, imitators have much more frequent interactions with others as shown in Table 4. Imitators take part in party play and trade more frequently than non-imitators in existence of spreaders in their friend lists.

Table 3. Game activities according to user classes

		Connection, #	Connection time	Level
spreader	Top 1%	340.5	695.71	55
	Top 10%	323	612.68	55
	Total	235	379.72	55
Total users		27	14.15	41

Furthermore, as we can see in Table 5, the interaction between spreaders and imitators is much stronger than that between spreaders and non-imitators in terms of interaction frequency.

Table 4. Game activities according to user classes

	Character, #	Party-play, #	Trade, #
Imitator	5,851	221	53
Non-imitator	54,222	5	1

Table 5. Game activities according to user relationship

	Party links, #	Avg. party-play, #	Trade links, #	Avg. trade, #
Spreader vs. Imitator	33,775	8.65	15,325	34.49
Spreader vs. Non-imitator	36,790	5.06	22,690	14.73

3. CONCLUSIONS

In this work, we aimed to characterize spreaders in MMORPGs. To this end, we explored the influential characteristics in terms of social interactions and game activity. To find out vital factors that make contagion between spreaders and imitators, we analyzed the interaction strength between them. Using a large amount of real data from a major MMORPG, we obtained the following findings from the empirical study: First, users who have many friends are not equal to those who have a high influence on others. Second, the induced sub-graph consisting of spreaders and imitators is a high-variance network. This implies that some users have much higher influence than others. Third, spreaders have high commitment in the game play. They play longer and more frequently. Fourth, the contagion occurs through frequent interactions between spreaders and imitators. In the future, from the perspective of network resilience, we will study how the diffusion process is affected by the removal of influentials. Tracking the changes of the influence network as influentials are removed will enable us to design a predictive and effective prevention strategy against bot users.

5. REFERENCES

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