Investigation of Users Suspected of Manipulating Evaluations of Answers in a Q&A Site

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Abstract—Some users in a question and answer (Q&A) site use multiple user accounts and attempt to manipulate communications in the site. In this paper, we first show a proper reason why many users in a Q&A site use multiple accounts from the viewpoint of personal data protection. On the other hand, we show some users can use multiple accounts inadequately and manipulate communications in the site. In order to detect these inadequate multiple account users precisely, we investigate them from two new points of view. First point of view is the number of accounts for submitting questions and manipulating evaluations of their answers. Second point of view is the deviations of answer submission order. We show these points of view are useful for detecting inadequate multiple account users precisely. The results of this study will give us a chance to investigate communication strategies of users in a Q&A site, especially, purposes and methods of inadequate multiple account users.

Keywords–multiple account; Q&A site; evaluation manipulation; anonymity.

I. INTRODUCTION

These days, many people use question and answer (Q&A) sites, where users share their information and knowledge. Q&A sites offer greater opportunities to users than search engines in the following points:

1) Users can submit questions in natural and expressive sentences, not keywords.
2) Users can submit ambiguous questions because other users give some supports to them.
3) Communications in Q&A sites are interactive. Users have chances to not only submit questions but give answers and, especially, join discussions.

As a result, Q&A sites are promising media. One of the essential factors in Q&A sites is anonymous submission. In most Q&A sites, user registrations are required for those who want to join the Q&A sites. However, registered users generally do not need to reveal their real names to submit messages (questions, problems, answers, comments, etc.). It is important to submit messages anonymously to a Q&A site. This is because anonymity gives users chances to submit messages without regard to shame and reputation. However, some users abuse the anonymity and attempt to manipulate communications in a Q&A site. For example, we showed some users use multiple user accounts and submit messages

to a Q&A site inadequately [1]. Manipulated communications discourage other submitters, keep users from retrieving good communication records, and decrease the credibility of the Q&A site. As a result, it is important to detect users suspected of using multiple user accounts and manipulating communications in a Q&A site. In this case, identity tracing based on user accounts is not effective because inadequate users are likely to hide their true identity to avoid detection. A possible solution is authorship identification based on analyzing stylistic features of messages. In recent years, a large number of studies have been made on authorship identification [2] [3] [4] [5] [6], however, few researchers addressed the identification issues of authors suspected of using multiple user accounts and manipulating communications in a Q&A site. To solve this problem, we proposed methods of detecting

- multiple account users suspected of submitting questions and their answers repeatedly [7], and
- multiple account users suspected of submitting many answers to the same question repeatedly [8].

However, little is known about the purposes and methods of inadequate multiple account users. As a result, it is important to investigate these inadequate multiple account users from various points of view. To solve this problem, we proposed two new points of view for investigating inadequate multiple account users [1] [9]. In this study, we discuss these two points of view further and introduce them together for detecting users suspected of manipulating evaluations of their answers precisely.

First point of view is whether these inadequate users use two or more accounts for submitting questions and manipulating evaluations of their answers [1]. It is natural for them to use multiple accounts for submitting questions. This is because too many good evaluations from one account may give strange impressions to other users and operators in the site. Inadequate users do not want to draw attention to themselves. As a result, in this paper, we investigate users suspected of using multiple user accounts for submitting many questions and manipulating evaluations of their answers.

Second point of view is whether these inadequate users use multiple user accounts in different ways [9]. Suppose that one user intends to advocate or justify his/her submitted answer and uses multiple user accounts as follows:

- a main account, and
- secondary accounts for advocating or justifying his/her answer submitted by the main account.

In this case, the deviation of answer submission order is likely to occur. As a result, we investigate user pairs who had large deviations of answer submission order and discuss the reasons why and how the deviations occurred.

Finally, we should notice that it is difficult to verify the credibility of our investigation. This is because there is no reliable information about users who used multiple user accounts and manipulated communications in Q&A sites. In order to discuss the credibility of our investigation, we show the results of our investigation in detail. The results of this study will give us a chance to investigate communication strategies of users in a Q&A site, especially, purposes and methods of inadequate multiple account users.

The rest of this paper is organized as follows: In Section II, we survey the related works. In Section III, we describe Yahoo! chiebukuro for an example of Q&A sites. In Section IV, we describe how inadequate users use multiple user accounts in Q&A sites. In Section V, we investigate user pairs suspected of using two or more accounts for submitting questions and manipulating evaluations of their answers. In Section VI, we investigate user pairs who had large deviations of answer submission order and discuss the reasons why and how the deviations occurred. In Section VII, we introduce the proposed points of view together and show that they are useful for investigating inadequate multiple account users in a Q&A site. Finally, in Section VIII, we present our conclusions.

II. RELATED WORKS

One of the essential factors of the Internet is anonymity. The author of [10] discussed the anonymity on the Internet from various points of view. The author of [11] pointed that anonymity is necessary in almost any protocol, application or service used in wired or wireless networks, and showed a survey on anonymity preserving solutions. These days, many users abuse the anonymity. Take a Sybil attack for example. In a Sybil attack, the attacker intends to gain large influence on a peer-to-peer (P2P) network by creating and using a large number of pseudonymous identities [12] [13]. Sybil attacks are cheap and efficient way to gain large influence on P2P networks [14]. Similarly, in human online communities, such as, web-based bulletin boards, chat rooms, and blog comment forms, many users are thought to use multiple user accounts inadequately and submit inadequate messages, such as, deceptive opinion spams. In recent years, a large number of studies have been made on authorship identification [2] [3] [4] [5] [6], however, few researchers addressed the identification issues of authors suspected of using multiple user accounts and manipulating communications in the Internet. One of the difficulties of this problem is that we did not have sufficient number of examples of inadequate multiple account users. To solve this problem, some researchers tried to extract inadequate submissions by using heuristic methods based on text similarities and ranking results [15] [16]. On the other hand, the authors of [17] pointed that these heuristic methods
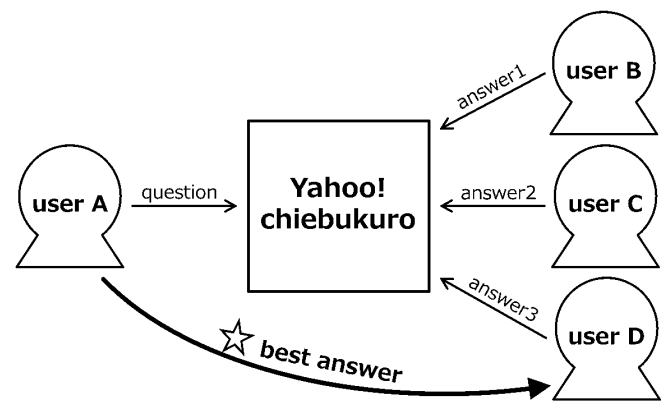

Figure 1. An example of how to use Yahoo! chiebukuro.

were insufficient to detect inadequate submissions precisely, and showed they could detect inadequate submissions precisely when they used large number of examples of inadequate submissions. However, they obtained examples of inadequate submissions by using Amazon Mechanical Turk [18]. The examples of inadequate submissions created by workers in Amazon Mechanical Turk have the following problems.

- Little is known about the purposes and methods of inadequate submissions. As a result, it is possible that their instructions to workers in Amazon Mechanical Turk were insufficient.
- There are unreliable workers in Amazon Mechanical Turk [19].

As a result, it is important to obtain inadequate submissions from the Internet. To solve this problem, we proposed methods of detecting inadequate multiple account users and their submissions [7] [8]. However, as mentioned, little is known about the purposes and methods of inadequate multiple account users. As a result, it is important to investigate these inadequate multiple account users and their inadequate submissions from various points of view.

III. YAHOO! CHIEBUKURO

Yahoo! chiebukuro is one of the most popular community sites in Japan. Users of Yahoo! chiebukuro submit their questions and answers in the next way.

- User registrations are required for those who want to join Yahoo! chiebukuro.
- Users do not need to reveal their real names to submit their questions and answers.
- User accounts of submitters are recorded and shown in their questions and answers.
- Each user can submit his/her answer only one time to one question.
- The period limit for accepting answers is one week. However, questioners can stop accepting answers before the time limits.
- After the time limits, questions with no answers are removed and cannot be referable. On the other hand, questions with answers can be referable.

TABLE I.   THE NUMBERS OF USERS AND THEIR SUBMISSIONS TO PC CATEGORY, SOCIAL ISSUES CATEGORY, AND ALL 286 CATEGORIES IN YAHOO! CHIEBUKURO (FROM APRIL/2004 TO OCTOBER/2005).

category	number of questioners	number of questions	number of answerers	number of answers
PC	43,493	171,848	27,420	474,687
social issues	13,259	78,777	25,766	403,306
all 286 categories	165,064	3,116,009	183,242	13,477,785

- Each questioner is requested to determine which answer to his/her question is best and give a *best answer* label to it.

Figure 1 shows that user A submitted one question to Yahoo! chiebukuro and three users, user B, user C, and user D answered the question, and then, user A selected user D's answer as a best answer. In this study, we used the data of Yahoo! chiebukuro for observation and examination. Chiebukuro means pearls of wisdom. The data of Yahoo! chiebukuro was published by Yahoo! JAPAN via National Institute of Informatics in 2007 [20]. This data consists of about 3.11 million questions and 13.47 million answers, which were posted on Yahoo! chiebukuro from April/2004 to October/2005. In the data, each question has at least one answer because questions with no answers were removed. In order to avoid identifying individuals, user accounts were replaced with unique ID numbers. By using these ID numbers, we can trace any user's questions and answers in the data. Table I shows

- the numbers of questioners and their questions in the data, and
- the numbers of answerers and their answers in the data.

In Table I, the number of questioners is the number of users who submitted one or more questions to Yahoo! chiebukuro from April/2004 to October/2005. Also, the number of answerers is the number of users who submitted one or more answers to Yahoo! chiebukuro from April/2004 to October/2005.

Furthermore, the following kinds of information are described in the data.

- submission time of question
- submission time of answer
- problem resolution time

Figure 2 shows an example of a series of events that occur after a questioner submits his/her question to Yahoo! chiebukuro. In Figure 2, the submission time of question q is t_q. Also, the submission time of answer a_1 and a_2 are t_{a1} and t_{a2}, respectively. Finally, the problem resolution time of question q is t_{pr}. At the problem resolution time, questioner Q stopped accepting answers and determined which answer was the best answer. By using these kinds of time information, we measured

- submission time lags between questions and their answers (e.g., $t_{a1} - t_q$ and $t_{a2} - t_q$ in Figure 2),
- submission time lags between answers submitted to the same question (e.g., $t_{a2} - t_{a1}$ in Figure 2), and
- answer submission order.

Figure 3 shows the cumulative relative frequency of the submission time lags between questions and their answers in
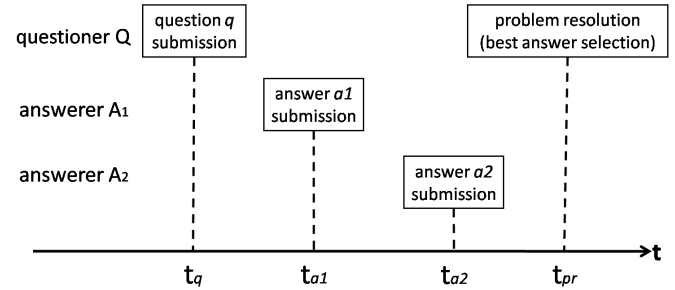
Questioner Q submitted question q at t_q. Also, answerer A_1 and A_2 submitted their answers at t_{a1} and t_{a2}, respectively. Finally, questioner Q stopped accepting answers and determined which answer was the best answer at t_{pr}.

Figure 2.   An example of a series of events that occur after a questioner submits his/her question to Yahoo! chiebukuro.

the data of Yahoo! chiebukuro. Also, Figure 4 shows the cumulative relative frequency of the submission time lags between answers submitted to the same question. As shown in Figure 4, the median of the submission time lags between answers submitted to the same question in social issues category was greater than those of PC category and all 286 categories. In social issues category, there were many answers criticizing or against previous answers. As a result, many answerers in this category made and submitted answers after they read other answers to the same question. We think this is one of the reasons why the median of the submission time lags between answers submitted to the same question in social issues category was greater than those of PC category and all 286 categories.

IV.   SUBMISSIONS BY USING MULTIPLE USER ACCOUNTS

There are many reasons why users in a Q&A site use multiple user accounts. First, we discuss a proper reason. In Yahoo! chiebukuro, users do not need to reveal their real names to submit their questions and answers. However, their submissions are traceable because their user accounts are attached to them. Because of this traceability, we can collect any user's submissions and some of them include clues of identifying individuals. Each clue (age, gender, location, occupation, hobby, health, and so on) is not sufficient to identify individuals, however, the combination of them is sometimes sufficient. As a result, to avoid identifying individuals and protect personal information, it is reasonable and proper that users change their user accounts or use multiple user accounts.
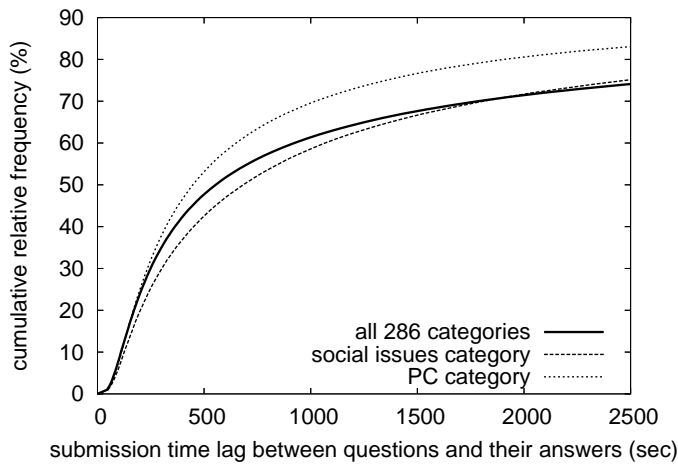
Figure 3. The cumulative relative frequency of the submission time lags between questions and their answers in social issues category, PC category, and all 286 categories of the data of Yahoo! chiebukuro.
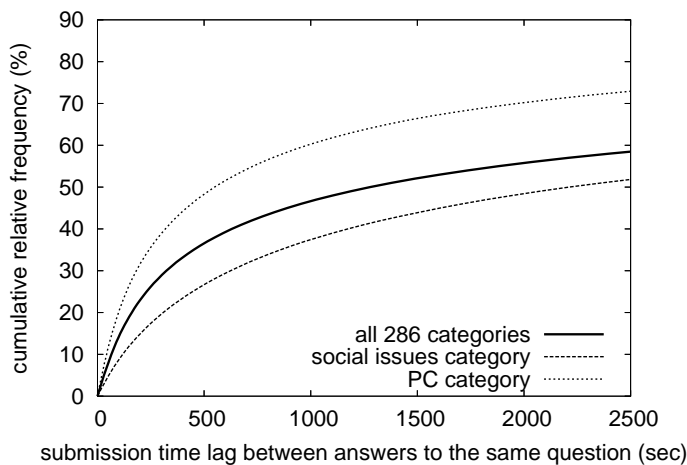

Figure 4. The cumulative relative frequency of the submission time lags between answers submitted to the same question in social issues category, PC category, and all 286 categories of the data of Yahoo! chiebukuro.

However, the following types of submissions by using multiple user accounts are neither reasonable nor proper.

TYPE QA One user submits a question and its answer by using multiple user accounts (Figure 5 (a)).
We think that the user intended to manipulate the submission evaluation. For example, in Yahoo! chiebukuro, each questioner is requested to determine which answer is best and give a *best answer* label to it. These evaluations encourage answerers to submit new answers and increase the credibility of the Q&A site. We think that the user repeated this type of submissions because he/she wanted to get many best answer labels and be seen as a good answerer.
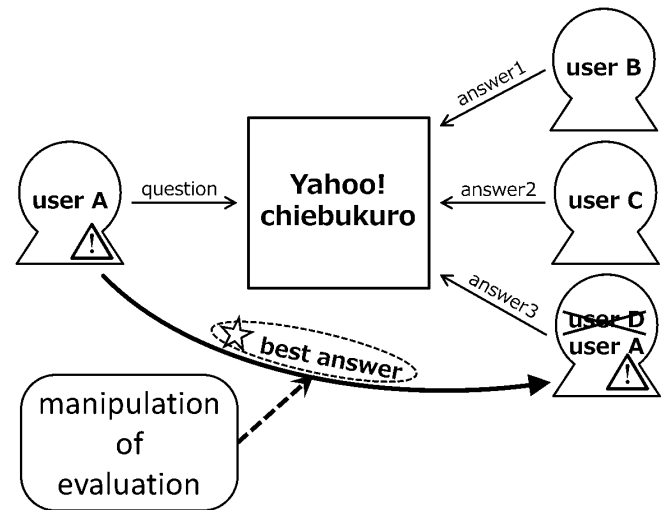
(a) TYPE QA: one user submits a question and its answer by using multiple user accounts. (In this case, user A submits a question and its answer by using two user accounts.)
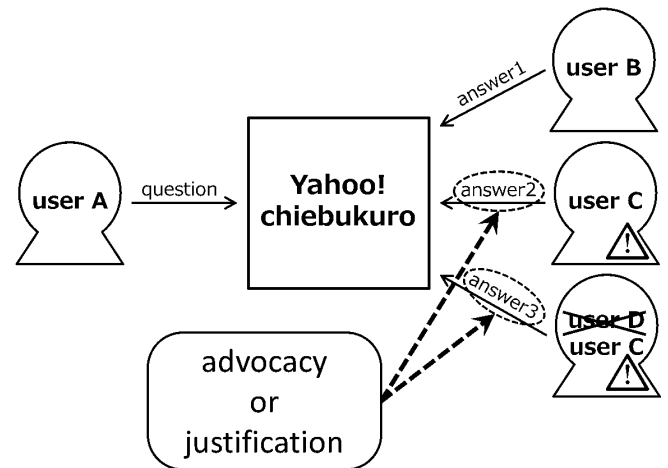
(b) TYPE AA: one user submits two or more answers to the same question by using multiple user accounts. (In this case, user C submits two answers by using two user accounts.)

Figure 5. Two types of inadequate submissions: TYPE QA and TYPE AA.

TYPE AA One user submits two or more answers to the same question by using multiple user accounts (Figure 5 (b)).
We think that the user intended to dominate or disrupt communications in the Q&A site. To be more precise, the user intended to

- manipulate communications by advocating or justifying his/her opinions, or
- disrupt communications by submitting two or more inappropriate messages.

TYPE AA submissions are more similar to Sybil attacks in P2P networks than TYPE QA submissions. The more answers inadequate users submit by using multiple user accounts, the easier they manipulate or disrupt communications in a Q&A site.

These two types are not all types of inadequate submissions. However, these kinds of submissions seriously disrupt communications in a Q&A site. For example, TYPE QA submissions are serious because users can manipulate evaluations of messages by repeating TYPE QA submissions. Manipulated evaluations discourage other submitters, keep users from retrieving good communication records, and decrease the credibility of the Q&A site. Furthermore, we think we cannot use knowledge and countermeasures obtained in studies of Sybil attacks in P2P networks because TYPE QA submissions are different from Sybil attacks. In a Sybil attack, the more pseudonymous identities the attacker uses, the easier he/she gain large influence on a P2P network. On the other hand, in a TYPE QA submission, the inadequate user can get a best answer label by using only two user accounts. To solve this problem, we proposed methods of detecting multiple account users suspected of repeating TYPE QA submissions [7]. However, little is known about the purposes and methods of inadequate multiple account users. As a result, it is important to investigate these inadequate multiple account users from various points of view. In this study, we introduce the following two points of view for investigating inadequate multiple account users.

- whether these inadequate users use multiple accounts for repeating TYPE QA submissions, and
- whether these inadequate users use multiple accounts in different ways for repeating TYPE AA submissions.

Furthermore, we investigate users detected based on these point of view and discuss whether these points of view are useful.

V. Detection of users suspected of using two or more accounts for submitting questions and manipulating evaluations

From the standpoint of the number of user accounts for submitting questions and manipulating evaluations of their answers, inadequate multiple account users who repeat TYPE QA submissions can be classified into two types:

- inadequate users each of whom uses only one user account for submitting questions and manipulating evaluations of his/her answers, and
- inadequate users each of whom uses two or more user accounts for submitting questions and manipulating evaluations of his/her answers.

In this section, we investigate the latter type of users, in other words, users suspected of using two or more user accounts for submitting questions and manipulating evaluations of their answers.

A. Basic idea

Suppose that one user intends to manipulate evaluations of his/her answers, submitted by using user account a, and repeats TYPE QA submissions by using two user accounts, q_1 and q_2. In this case, it is expected that we observe the following unusual submissions:

- user a submits too many answers to questions submitted by user q_1 and q_2,
- user q_1 and q_2 receive too many answers from user a, and
- user q_1 and q_2 give too many best answer labels to user a's answers.

Taking account of these points, we detect users suspected of using two or more user accounts for submitting questions and manipulating evaluations of their answers in the next way. We first detect user pairs suspected of repeating TYPE QA submissions. Then, we detect answerers who are found in two or more of the detected user pairs. The detected answerers are suspected of using two or more user accounts for submitting questions and manipulating evaluations of their answers.

B. Detection of users suspected of using two or more user accounts for submitting questions and manipulating evaluations of their answers

In order to detect users who intend to manipulate evaluations of their answers and submit many questions by using two or more user accounts, we propose a method that consist of the following two steps:

1) We first detect user pairs of a questioner and an answerer, who are suspected of repeating TYPE QA submissions, as shown in Figure 5, by using three hypotheses: Hypothesis QA1, QA2, and QA3.
2) We detect users who are answerers in two or more user pairs detected by using Hypothesis QA1, QA2, and QA3.

Hypothesis QA1, QA2, and QA3 are as follows:

[Hypothesis QA1] If user a did not submit unusually too many answers to user q's questions, we would expect that user a submitted at most $N_{QA1}(q, a)$ answers to user q's questions.

$$N_{QA1}(q, a) = P_{QA1}(q) \times ans(a) \qquad (1)$$

where $ans(a)$ is the total number of answers submitted by user a and $P_{QA1}(q)$ is the probability that an user selects one question randomly and the question is one of user q's questions. Because each user of Yahoo! chiebukuro can submit his/her answer only one time to one question, $P_{QA1}(q)$ is

$$P_{QA1}(q) = \frac{qst(q)}{N_{qst}} \qquad (2)$$

where $qst(q)$ is the number of questions submitted by user q and, as shown in Table I, N_{qst} is the total number of questions in the data of Yahoo! chiebukuro. If this hypothesis is rejected by an one-sided binomial test, we determine that user a submitted unusually too many answers to user q's questions.

The binomial test is an exact test of the statistical significance of deviations from a theoretically expected binomial distribution of observations into two categories [21]. There are two types of binomial tests: one sided binomial tests or two sided binomial tests. When the critical area of a distribution is one-sided, in other words, it is either greater than or less than

TABLE II.   THE DETECTION RESULT OF USERS SUSPECTED OF USING TWO OR MORE USER ACCOUNTS FOR SUBMITTING QUESTIONS AND MANIPULATING EVALUATIONS OF THEIR ANSWERS

significance levels for QA1, QA2, QA3, and QA3aux	UP_{QA}	UP_{QA2+}	A_{QA}	A_{QA2+}
5×10^{-5}	814	329	581	96
1×10^{-5}	603	222	450	69
5×10^{-6}	537	188	408	59
1×10^{-6}	424	135	333	44
5×10^{-7}	407	129	319	41
1×10^{-7}	337	104	266	33
5×10^{-8}	325	101	257	33
1×10^{-8}	278	86	220	28

UP_{QA} is the number of user pairs who are detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. UP_{QA2+} is the number of user pairs the answerers of whom were found in two or more user pairs detected by binomial tests. A_{QA} is the number of answerers who are found in user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. A_{QA2+} is the number of answerers who are found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux.

a certain value, but not both, only an one-sided binomial test is generally applicable. In this study, the distribution area is one-sided, we use the one-sided binomial test.

[Hypothesis QA2]   If user q did not receive unusually too many answers from user a, we would expect that user q received at most $N_{QA2}(q, a)$ answers from user a.

$$N_{QA2}(q, a) = P_{QA2}(a) \times qst(q) \qquad (3)$$

where $qst(q)$ is the total number of questions submitted by user q and $P_{QA2}(a)$ is the probability that an user received one answer from user a when user a selected one question randomly and answered it. Because each user of Yahoo! chiebukuro can submit his/her answer only one time to one question, $P_{QA2}(a)$ is

$$P_{QA2}(a) = \frac{ans(a)}{N_{qst}} \qquad (4)$$

where $ans(a)$ is the number of answers submitted by user a and, as shown in Table I, N_{qst} is the total number of questions in the data of Yahoo! chiebukuro. If this hypothesis is rejected by an one-sided binomial test, we determine that user q received unusually too many answers from user a.

[Hypothesis QA3]   If user q did not give unusually too many best answer labels to user a's answers, we would expect that user q gave at most $N_{QA3}(q, a)$ best answer labels to user a's answers.

$$N_{QA3}(q, a) = P_{QA3}(q) \times f_{QA}(q, a) \qquad (5)$$

where $f_{QA}(q, a)$ is the number of answers submitted by user a to user q's questions, and $P_{QA3}(a)$ is the best answer ratio of user a.

$$P_{QA3}(a) = \frac{bestans(a)}{ans(a)} \qquad (6)$$

where $ans(a)$ is the number of answers submitted by user a and $bestans(a)$ is the number of best answers in user a's answers. However, if user j satisfies one of the following conditions:

- all user a's answers were selected as best answers, in other words,

$$ans(a) = bestans(a) \qquad (7)$$

- Hypothesis QA3aux, the auxiliary hypothesis for Hypothesis QA3, is rejected, in other words, it is considered that user a received too many best answer labels,

we set $P_{QA3}(a)$ as follows:

$$P_{QA3}(a) = \frac{N_{bestans}}{N_{ans}} = \frac{N_{qst}}{N_{ans}} \qquad (8)$$

where $N_{bestans}$ is the total number of best answers. $N_{bestans}$ is equal to N_{qst} because each question has one best answer. If this hypothesis is rejected by an one-sided binomial test, we determined that user q gave unusually too many best answer labels to user a's answers.

[Hypothesis QA3aux]   If user a did not receive unusually too many best answer labels, we would expect that user a received at most $N_{QA3aux}(a)$ best answer labels.

$$N_{QA3aux}(a) = P_{QA3aux} \times ans(a) \qquad (9)$$

where P_{QA3aux} is the average best answer ratio.

$$P_{QA3aux} = \frac{N_{bestans}}{N_{ans}} = \frac{N_{qst}}{N_{ans}} \qquad (10)$$

If this hypothesis is rejected by an one-sided binomial test, we consider that user a received unusually too many best answer labels.

C. Result of the Investigation

To evaluate our method, we conducted the detection of users suspected of using two or more user accounts for submitting many questions and repeating TYPE QA submissions, and manipulating evaluations of their answers in a Q&A site. In this experiment, the target users were all submitters in the data of Yahoo! chiebukuro. As shown in Table I, the numbers of the target questioners and answerers in the data of Yahoo! chiebukuro are 165,064 and 183,242, respectively.

In our method, we varied the significance levels for Hypotheses QA1, QA2, QA3, and QA3aux from 5×10^{-5} to 1×10^{-8}. They were extremely low because we intend to detect extreme unusual submissions. Table II shows the results of this experiment.

As shown in Table II, 59 users were detected when the significance level was 5×10^{-6}. We should notice that 28 users of them were detected when the significance level was 1×10^{-8}. It shows that many users were detected although the significance level was extremely low. As we expected, there are many users suspected of repeating TYPE QA submissions and manipulating evaluations of their answers by using two or more user accounts for submitting questions.

We checked questions and answers submitted by the detected user pairs and found that some questioners were criticized for their unfair best answer selections. For example, user 233650 was criticized that he/she selected user 678451's answers as best answers repeatedly and unfairly. After criticized for his/her unfair best answer selection, user 233650 stopped submitting any questions to Yahoo! chiebukuro. Our method is useful for detecting these suspicious users. Furthermore, if we detect and take care of these suspicious users, we can avoid unnecessary frictions between users.

VI. DETECTION OF TOO LARGE DEVIATIONS OF ANSWER SUBMISSION ORDER

Inadequate users repeating TYPE QA submissions are likely to use multiple user accounts as follows:

- main accounts, and
- secondary accounts for submitting questions and manipulating evaluations of main accounts.

On the other hand, little is known how inadequate users repeating TYPE AA submissions use multiple user accounts. To solve this problem, in this study, we investigate whether inadequate users repeating TYPE AA submissions used multiple user accounts in different ways as inadequate users repeating TYPE QA submissions did, and discuss the purposes and methods of them.

If one user uses multiple user accounts in different ways, some deviations are likely to occur. Suppose that one user intends to advocate or justify his/her submitted answer and uses multiple user accounts as follows:

- a main account, and
- secondary accounts for advocating or justifying his/her answer submitted by the main account.

In this case, the user is likely to submit first answers from his/her main account and other answers from their secondary accounts. In order to detect this kind of inadequate users, we introduce *deviation of answer submission order*.

[deviation of answer submission order] Suppose user i and user j submitted their answers to the same N questions, and, user i submitted N_i answers earlier than user j and user j submitted N_j answers earlier than user i. The deviations of answer submission order of this user pair is $N_i - N_j$.

In this study, we investigate user pairs who had large deviations of answer submission order. This is because, we

think, deviations of answer submission order give us a chance to learn inadequate multiple account users from the new point of view.

In Yahoo! chiebukuro, there were many questions the purpose of which was to collect opinions. For example,

(Q)   What do you think about Prime Minister Koizumi? He has maintained high approval ratings and does well in his work.

This kind of question often had many answers. Some of them were criticizing or against previous answers. Because of such critical submissions, some users were likely to use multiple user accounts and submit new answers for advocating or justifying their previous answers. We think some users used multiple user accounts as follows:

- main accounts, and
- secondary accounts for advocating or justifying their answer submitted by the main accounts.

This is because it is easy to manage multiple user accounts. When multiple user accounts were used as above, it is easy to avoid submitting new answers that were inconsistent with the previous answers. Inconsistent answers often gave suspicious impressions to others. However, if multiple user accounts were used in this way, the deviation of answer submission order is likely to occur. As a result, in this study, we investigate user pairs who had large deviations of answer submission order and discuss the reasons why and how the deviations occurred.

A. Basic idea

In order to detect users who were suspected of repeating TYPE AA submissions by using multiple user accounts in different ways, we introduce two ideas. If one user repeated TYPE AA submissions too many times by using two user accounts, user i and user j, it is expected that

(idea 1) user i and user j submit too many answers to the same questions together.

Furthermore, if the user used these two user accounts in different ways, it is expected that

(idea 2) there are too large deviations of answer submission order between user i and user j.

Based on these two ideas, we determine whether users repeated TYPE AA submissions by using multiple user accounts in different ways.

B. Most frequently encountered user

In order to explain our method of detecting too large deviations of answer submission order, we introduce the term *most frequently encountered user*.

Many users have other users who submitted answers to the same questions with them. We will use the term *most frequently encountered user* of a certain user to refer to a user who submitted answers to the same questions most frequently with the user.

[most frequently encountered user] Suppose user i submitted answers to the same questions with N users ($k = 1, \cdots, N$), and, among them, most frequently with user j.

$$mfe(i) = \max_{k \in N} N_{ans\_together}(i, k) = j$$

where $mfe(i)$ is the most frequently encountered user of user i and $N_{ans\_together}(i, k)$ is the number of questions to which user i and k submitted answers together. N_{mfe} is the total number of each user's answers that were submitted with his/her most frequently encountered user. For example, N_{mfe} is 74,781 in social issues category. As a result, it is expected that, when a user submitted 100 answers to social issues category, the user and his/her most frequently encountered user submitted

$$\frac{N_{mfe}}{N_{ans}} \times 100 = \frac{74781}{403306} \times 100 = 18.5$$

answers together to the same questions.

C. Detection of user pairs who submitted too many answers to the same questions

As mentioned, if one person used two user accounts, user i and user j, and repeated TYPE AA submissions in a Q&A site too many times, it is expected that we observe unusual submissions:

- user i submitted unusually too many answers to the same questions with user j.

To detect these unusual submissions, we test one hypothesis: Hypothesis AA.

[Hypothesis AA] If user i did not submit unusually too many answers to the same questions with user j, we would expect that user i submitted at most $N_{AA}(i)$ answers to the same questions with user j.

$$N_{AA}(i) = \frac{N_{mfe}}{N_{ans}} \times ans(i)$$

where $ans(i)$ is the total number of answers submitted by user i. N_{ans} is the total number of answers submitted to the category, and N_{mfe} is the total number of each user's answers that were submitted with his/her most frequently encountered user. If this hypothesis is rejected by an one-sided binomial test, we determine that user i submitted unusually too many answers to the same questions with user j.

D. Detection of user pairs who had too large deviations of answer submission order

If one user repeated TYPE AA submissions by using two user accounts, user i and user j, in different ways, it is expected that we observe

- too large deviations of answer submission order between user i and user j.

To detect too large deviations of answer submission order between user i and user j, we test one hypothesis: Hypothesis AASO.

[Hypothesis AASO] Suppose that there are $N_{AA}(i, j)$ cases where user i and user j submitted their answers to the same question. If one of these users did not submit answers too many times before the other did, we would expect that there are at most $N_{AASO}(i, j)$ cases where one user submitted his/her answer before the other did.

$$N_{AASO}(i, j) = P_{AASO}(i, j) \times N_{AA}(i, j)$$

where $P_{AASO}(i, j)$ is the probability that one user submitted an answer before the other did. In this study, $P_{AASO}(i, j)$ was set to 0.5. In other words, user i and user j have equal probability that one user submitted an answer before the other did. If this hypothesis is rejected by a two-sided binomial test, we determine that one of these users, user i or user j, submitted answers unusually too many times before the other did.

E. Result of the investigation

In order to detect too large deviations of answer submission order, we test Hypothesis AA and AASO. In this study, the target user pairs are 23,053,308 user pairs each of whom submitted answers to at least one same question in Yahoo! chiebukuro. The significance level for Hypothesis AA was extremely low: 5×10^{-6}. This is because we intend to detect extreme unusual submissions. On the other hand, the significance level for Hypothesis AASO was 1×10^{-2}.

In this experiment, we first applied Hypothesis AA on 23,053,308 user pairs in Yahoo! chiebukuro, and detected 790 user pairs who repeated submitting answers to the same question too many times. Then, we applied Hypothesis AASO on these 790 user pairs and detected 382 user pairs who had too large deviations of answer submission order. In order to discuss the detection results in detail, we take the result in social issues category for example. This is because there were many discussions between answerers in this category. As a result, it seems more likely that some multiple account users intended to advocate or justify their answers and repeated TYPE AA submissions in this category. The target user pairs in social issues category are 828,812 user pairs. We applied Hypothesis AA on these 828,812 user pairs and detected 20 user pairs who repeated submitting answers to the same question too many times. Then, we applied Hypothesis AASO on these 20 user pairs and detected 7 user pairs who had too large deviations of answer submission order. Table III shows the result of the investigation on these 7 user pairs. In Table III, user A_1 mainly submitted answers before user A_2 did. $N_{AA}(A_1, A_2)$ is the number of questions to which both user A_1 and user A_2 submitted answers. $NE_{AA}(A_1, A_2)$ is the number of questions where user A_1 submitted answers before user A_2 did. $T_{QA}(A_1, A_2)$ is the median of submission time lags between questions and the earlier of their answers of A_1 or A_2. $T_{AA}(A_1, A_2)$ is the median of submission time lags between answers of A_1 and A_2 submitted to the same question. Figure 3 shows the cumulative relative frequency of submission time lags between questions and their answers. Also, Figure 4 shows the cumulative relative frequency of submission time lags between answers submitted to the same question. By considering the similarity of writing styles and opinions, we determined whether each user pair is one and the same user or not. Decision shows our judgements. We discuss

- whether each of these 7 user pairs is one and the same user or not,
- the purposes of inadequate multiple account users, and
- the reasons why and how the deviations of answer submission order occurred

in detail below.

TABLE III.   THE RESULT OF THE INVESTIGATION ON THE 7 USER PAIRS WHO HAD TOO LARGE DEVIATIONS OF ANSWER SUBMISSION ORDER.

A_1	A_2	$N_{AA}(A_1, A_2)$	$NE_{AA}(A_1, A_2)$	$T_{QA}(A_1, A_2)$	$T_{AA}(A_1, A_2)$	decision
691911	802184	47	43	5.1 min.	83 sec.	same user
267614	76731	62	44	22 min.	22 min.	same user
458523	518681	86	61	9.0 min.	26 min.	different users
414445	733881	20	18	4.0 min.	2.3 hrs.	different users
649164	622996	40	30	6.6 hrs.	30 hrs.	same user
471690	471692	12	11	16 hrs.	50 hrs.	same user
622996	471692	12	11	18 hrs.	74 hrs.	different users

$N_{AA}(A_1, A_2)$ is the number of questions to which both user A_1 and A_2 submitted answers. $NE_{AA}(A_1, A_2)$ is the number of questions where user A_1 submitted answers before user A_2 did. $T_{QA}(A_1, A_2)$ is the median of submission time lags between questions and the earlier of their answers of A_1 or A_2. $T_{AA}(A_1, A_2)$ is the median of submission time lags between answers of A_1 and A_2 submitted to the same question. Decision shows our judgements. By considering the similarity of writing styles and opinions, we determined whether each user pair is one and the same user or not.

User pair (267614, 76731) submitted many answers to the questions about foreign residents in Japan. We determined that user 267614 and 76731 were one and the same user. This is because their writing styles and opinions were quite similar and their answers often included special words, for example, personal HP and comic artists, which other users did not cover in this category. These accounts were likely to be used for repeating the same words. For example,

[Q: 654871]   I found this exhibitor in the auction [URL]. I think it is against the rule.
[A: 76731]   It is scratchbuild. Let it go. You are a snitch.
[A: 267614]   You are like a snitch in North Korea. Or a hound.

We thought there was plenty of this kind of inadequate users in Yahoo! chiebukuro. Our method detected user pair (267614, 76731), however, it was not enough. This is because we did not think of any reasons why this kind of users used their multiple user accounts in this way. We are searching more examples of this kind of inadequate users and intend to find the reasons.

Also, in case of user pair (691911, 802184), we determined these users were one and the same user. This is because the median of submission time lags between their answers was only 83 seconds although user 691911 submitted answers at different times of a day. In addition, user pair (691911, 802184) had too large deviations of answer submission order in 9 categories, including social issues category. Furthermore, when user 691911 submitted questions, user 691911 selected user 802184's answers as best answers in too many times in various categories. In addition, like the case of user pair (267614, 76731), these accounts were likely to be used for repeating the same words.

In contrast, in cases of user pair (458523, 518681) and (414445, 733881), we determined that the users of each pair were different users. This is because we found many opinion conflict between the users of each pair. Each pair used Yahoo! chiebukuro almost at the same time of each day. For example, user 458523 and 518681 mainly used Yahoo! chiebukuro from 8:00 am to 5:00 pm. Also, user 414445 and 733881 mainly used Yahoo! chiebukuro from 8:00 pm to 1:00 am. As a result, the users of each pair read questions almost at the same time. On the other hand, the median of submission time lags from questions to user 458523's answers and user 518681's answers were 9.9 minutes and 28 minutes, respectively. Also,
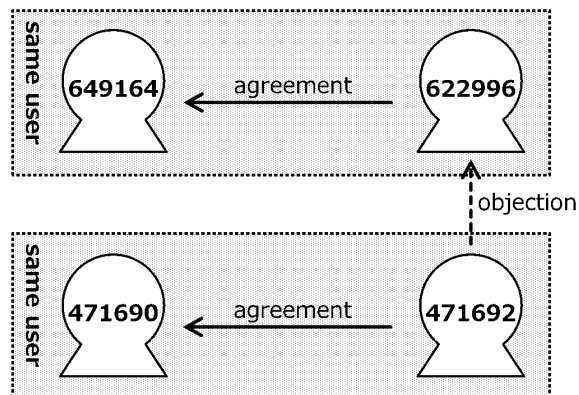

Figure 6.   The relation between user pair (649164, 622996) and (471690, 471692).

the median of submission time lags from questions to user 414445's answers and user 733881's answers were 7.4 minutes and 66 minutes, respectively. We think that these time lags gave the deviations of answer submission order between the users of each user pair.

Both user pair (649164, 622996) and (471690, 471692) submitted answers repeatedly to questions about a certain religious group. We determined that the users of each pair were one and the same users. This is because they had similar writing styles and opinions respectively. Especially, there was only one opinion conflict between user 649164 and 622996 just after they were pointed out that they were one and the same user. As shown in Table III, user 622996 and 471692 mainly submitted their answers after user 649164 and 471690 did, respectively. In both cases, two user accounts were used in different ways as follows:

- main accounts (user 649164 and 471690), and
- secondary accounts (user 622996 and 471692) for criticizing other users' answers, or advocating or justifying answers submitted by the main accounts

and repeated TYPE AA submissions. Especially, user 471692 often criticized user 622996's answers. As a result, user pair (622996, 471692) was detected although the users of this pair were different users and had different opinions. Figure 6 shows

TABLE IV. THE DETECTION RESULT OF USER PAIRS DETECTED BY USING THE METHODS DESCRIBED IN SECTION V AND SECTION VI.

significance levels for QA1, QA2, QA3, and QA3aux	UP_{QA}	UP_{QA2+}	UP_{QA2+AA}
5×10^{-5}	814	329	6
1×10^{-5}	603	222	6
5×10^{-6}	537	188	6
1×10^{-6}	424	135	5
5×10^{-7}	407	129	5
1×10^{-7}	337	104	5
5×10^{-8}	325	101	5
1×10^{-8}	278	86	5

UP_{QA} is the number of user pairs who are detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. UP_{QA2+} is the number of user pairs the answerers of whom were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. UP_{QA2+AA} is the number of user pairs (1) the answerers of whom were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux and (2) who were detected by binomial tests based on Hypothesis AA and AASO.

TABLE V. THE DETECTION RESULT OF ANSWERERS BELONG TO USER PAIRS DETECTED BY USING THE METHODS DESCRIBED IN SECTION V AND SECTION VI.

significance levels for QA1, QA2, QA3, and QA3aux	A_{QA}	A_{QA2+}	A_{QA2+AA}
5×10^{-5}	581	96	4
1×10^{-5}	450	69	4
5×10^{-6}	408	59	4
1×10^{-6}	333	44	4
5×10^{-7}	319	41	4
1×10^{-7}	266	33	4
5×10^{-8}	257	33	4
1×10^{-8}	220	28	4

A_{QA} is the number of answerers belong to user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. A_{QA2+} is the number of answerers who were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. A_{QA2+AA} is the number of answerers (1) who were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux and (2) who belong to user pairs detected by binomial tests based on Hypothesis AA and AASO.

the relation between user pair (649164, 622996) and (471690, 471692).

VII. DETECTION OF INADEQUATE MULTIPLE ACCOUNT USERS FROM NEW POINTS OF VIEW

In this section, we introduce the two points of view, described in Section V and Section VI, together for investigating inadequate multiple account users in a Q&A site and discuss the effectiveness of them.

Table IV shows the number of user pairs

- the answerers of whom were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux and
- who were detected by binomial tests based on Hypothesis AA and AASO.

Table V shows the number of answerers

- who were found in two or more user pairs detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux and
- who belong to user pairs detected by binomial tests based on Hypothesis AA and AASO.

We take the result under the significance level of 5×10^{-6} for example. As shown in Table IV, when the significance level was 5×10^{-6}, 537 user pairs were detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. Among them, we found 188 user pairs the answerers of whom were found in two or more user pairs detected by the binomial tests. Among them, the following 6 user pairs were detected by binomial tests based on Hypothesis AA and AASO.

- user pair (236956, 32780),
- user pair (494870, 434516),
- user pair (302153, 434516),
- user pair (652657, 528067),
- user pair (479505, 528067), and
- user pair (691911, 802184).

The first users of them were questioners and the second users were answerers when they were detected by binomial tests based on Hypothesis QA1, QA2, QA3, and QA3aux. The accounts of these answerers are thought to be main accounts of inadequate multiple account users. In this experiment, we varied the significance levels for Hypotheses QA1, QA2, QA3, and QA3aux from 5×10^{-5} to 1×10^{-8}. However, as shown in Table V, four answerers (user 32780, 434516, 528067, and

TABLE VI. THE NUMBER OF ANSWERS AND BEST ANSWERS OF THE 6 USER PAIRS DETECTED BY USING THE METHODS DESCRIBED IN SECTION V AND SECTION VI.

Q	A	$ans(A)$	$N_{BA}(Q, A)$	$N_A(Q, A)$
236956	32780	457	275	282
494870	434516	88	67	69
302153	434516	20	9	9
652657	528067	743	95	199
479505	528067	448	55	110
691911	802184	146	143	146

$ans(A)$ is the total number of answerer A's answers in Yahoo! chiebukuro. $N_A(Q, A)$ is the number of answerer A's answers that were submitted to questioner Q's questions. $N_{BA}(Q, A)$ is the number of answerer A's best answers that were selected by questioner Q.

TABLE VII. THE DEVIATIONS OF ANSWER SUBMISSION ORDER OF THE 6 USER PAIRS DETECTED BY USING THE METHODS DESCRIBED IN SECTION V AND SECTION VI.

A_1	A_2	$N_{AA}(A_1, A_2)$	$NE_{AA}(A_1, A_2)$	$T_{QA}(A_1, A_2)$	$T_{AA}(A_1, A_2)$	category
236956	32780	22	2	5.0 min.	6.6 min.	healthcare
494870	434516	54	0	20 min.	2.3 hrs.	language
302153	434516	19	0	31 min.	5.0 hrs.	language
652657	528067	89	73	6.5 min.	38 min.	Yahoo! auction
479505	528067	104	87	11 min.	33 min.	Yahoo! auction
691911	802184	281	242	6.5 min.	27 min.	general issues
691911	802184	180	131	12 min.	9.8 min.	TV and radio
691911	802184	129	94	11 min.	4.7 min.	entertainer
691911	802184	81	54	11 min.	7.7 min.	people in the news
691911	802184	66	49	6.3 min.	2.7 min.	baseball
691911	802184	47	43	5.1 min.	83 sec.	social issues
691911	802184	36	27	10 min.	15 min.	language
691911	802184	10	10	19 min.	10 min.	mental health
691911	802184	38	30	8.7 min.	4.2 min.	domestic issues

$N_{AA}(A_1, A_2)$ is the number of questions to which both user A_1 and A_2 submitted answers. $NE_{AA}(A_1, A_2)$ is the number of questions where user A_1 submitted answers before user A_2 did. $T_{QA}(A_1, A_2)$ is the median of submission time lags between questions and the earlier of their answers of A_1 or A_2. $T_{AA}(A_1, A_2)$ is the median of submission time lags between answers of A_1 and A_2 submitted to the same question.

802184) were detected in each case. The result shows that there are few users who used secondary accounts for repeating both TYPE QA and TYPE AA submissions. This is because inadequate users do not want to draw attention to themselves.

Next, we investigate the detected 6 user pairs. Table VI shows the number of answers and best answers of them. On the other hand, Table VII shows the deviations of answer submission order of them. We determined that each user pair was one and the same user. We show the reasons in detail below.

First, we discuss user pair (691911, 802184). In Section VI, we determined user 691911 and user 802184 were one and the same user. This is because the median of submission time lags between their answers in social issues category was only 83 seconds although user 691911 submitted answers at different times of a day. Furthermore, as shown in Table VI, user 691911 received 146 answers from user 802184, and selected 143 answers of them as best answers. Also, as shown in Table VII, this user pair had large deviations of answer submission order in 9 categories. In addition, user 691911 submitted many questions about the meaning of technical terms. For example,

[Q: 691911]   I have a question about earthquakes. What is the difference between earthquake intensity and

magnitude?
[A: 802184]   I show you a nice site for information about earthquakes. Visit the site at
http://www.kishou.go.jp/know/faq/faq7.html

http://www.kishou.go.jp/know/faq/faq7.html is the uniform resource locator (URL) of the frequently asked questions (FAQ) page on the site of the Japan Meteorological Agency. User 691911 submitted 10 questions (including this question) in a row and received 10 answers from user 802184, each of which showed the URL of the Japan Meteorological Agency FAQ page. User 691911 selected all these answers as best answers. The reason why this user submitted trivial questions like them is thought that the user wanted to increase the number of his/her best answers without drawing attention to himself/herself.

Next, we discuss user pair (236956, 32780). As shown in Table VI, user 236956 received 282 answers from user 32780 and selected 275 answers of them as best answers. Also, user pair (236956, 32780) had large deviations of answer submission order. Furthermore, user 236956 received the following two answers from user 443403.

[A: 443403]   I am quite sure that the first answerer will commit a criminal act!

[A: 443403] Are you guys all fools?????????????????

In both answers, user 443403 criticized other answerers. It is noteworthy that user pair (443403, 32780) was detected by binomial tests based on Hypothesis QA1, QA2, and QA3. We think that user 32780, user 236956, and user 443403 are one and the same user. It may be not enough for the user to select his/her answers as best answers and show that he/she is a good answerer. The user could not help but criticize other users. In other words, the user did TYPE QA submission and TYPE AA submission at the same time.

Next, we discuss user pair (494870, 434516) and user pair (302153, 434516). User pair (302153, 434516) was not detected when the significance level was less than 5×10^{-6}. However, we think user 302153, user 434516, and user 494870 are one and the same user. This is because we found examples where the user did TYPE QA submission and TYPE AA submission at the same time. For example, user 494870 received an answer in which user 434516's answer was criticized. Then, user 302153 submitted the following answer as if he/she was criticized.

[A: 302153] What are you talking about? Can you show BA right now? This is a grammar problem. "need to study more", who do you think you are?

User 302153 submitted 14 answers to user 494870's questions and in many of them he/she criticized other users as he/she did in this answer.

Finally, we discuss user pair (652657, 528067) and user pair (479505, 528067). As shown in Table VI, user 652657 received 199 answers from user 528067 and selected 95 answers of them as best answers. Also, user 479505 received 110 answers from user 528067 and selected 55 answers of them as best answers. In both cases, the best answer ratios were unusually high, however, they were lower than those of the other 4 detected user pairs. As a result, in order to determine whether user 479505, user 528067, and user 652657 are one and the same user or not, it is important to discuss the reason why the best answer ratios were low. Until August 2005, user 652657 submitted his/her questions to various categories, such as adult issues category and baseball category, and received 22 answers from user 528067 and selected 20 answers of them as best answers. On the other hand, from September 2005, user 652657 and user 479505 submitted their questions mainly to Yahoo! auction category and often did not select user 528067's answers as best answers. In Yahoo! auction category, user 652657 and user 479505 often submitted questions about violative items in Yahoo! auction, especially, used underwears. For example,

[Q: 652657] Oh, No! Violative item! Do something! [URL]
[A: 528067] So, report it by yourself. [URL] [URL]

[URL] is the URL to the page of the violative item. User 528067 showed the URL twice in this example. The question seemed to be the report of the violative item in Yahoo! auction. However, many other users thought that the user aimed to advertise the violative item. As a result, many answers of protest were submitted to user 652657's subsequent questions.

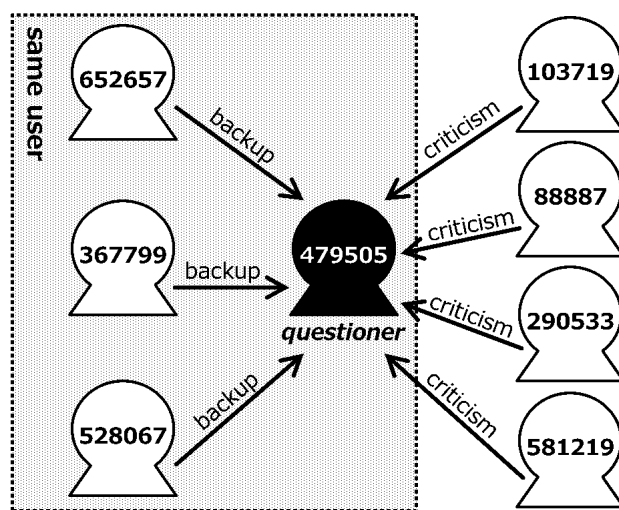[Q: 479505] I found a traditional store in this field. How amazing! [URL]

Figure 7.   The relations of users who submitted answers to user 479505's question.

[A: 103719] You dummy. So what?
[A: 652657] Prestige store !!!!!!!!!!!!!!!!!!!!!!!! [URL]
[A: 88887]   No advertisement. No advertisement. No advertisement.
[A: 290533]   What do you mean? I didn't get your point. Is it because the seller received high evaluations?
[A: 581219] Advertisement?
[A: 367799]   As long as there are violations, please report them. I'll be rooting for you.
[A: 528067] Get it eliminated. [URL] [URL]

In this example, user 479505 received 7 answers from 7 users. 4 answerers of them criticized user 479505. User 88887 and user 581219 accused user 479505 of advertising violative items. Also, user 103719 and user 290533 criticized user 479505 for submitting the ulterior question. On the other hand, two of the other 3 answerers, user 652657 and user 528067, were suspected of being the same user. Also, user 528067 was suspected of being the same user as the questioner, user 479505. Furthermore, user 367799 was suspected of being the same user as user 528067. This is because user pair (367799, 528067) was detected by binomial tests based on Hypothesis QA1, QA2, and QA3. As a result, user 367799, user 479505, user 528067, and user 652657 were suspected of being the same user. Figure 7 shows the relations of users in this example. Until September 2005, the user seemed to select his/her answers as best answers eagerly. However, in the example above, the user seemed to submit one question and three answers although he/she could select only one answer as a best answer. Actually, in this example, user 367799's answer was selected as a best answer. It is thought that his/her submission reason was changed from the best answer collection to the advertisement of auction items. As a result, the best answer ratio was lower than those of other user pairs suspected of being inadequate multiple account users. In our previous studies [7] [8], we put off the decision about whether

user 479505, user 528067, and user 652657 were one and the same user or not because the best answer ratios of them were lower than those of other detected user pairs. However, by introducing new points of view, we determined that these users were the same user. Furthermore, we collected the examples that show that the advertisement is one of the reasons for using multiple user accounts inadequately. As a result, it is important to investigate inadequate multiple account users from various points of view.

VIII. CONCLUSION

In this study, we investigated users suspected of using multiple user accounts and manipulating evaluations of their answers from various points of view. We first discussed reasons why users in a Q&A site use multiple user accounts. We think many users use multiple user accounts reasonably and properly, however, some users use them improperly. For example, there are many users suspected of using two or more user accounts for submitting questions and manipulating evaluations of their answers. In order to detect inadequate multiple account users, we proposed two detection methods [7] [8]. However, little is known about the purposes and methods of inadequate multiple account users. Actually, we found some suspicious users in our previous studies, however, it was difficult to determine whether they were inadequate multiple account users because of insufficient information. To solve this problem, it is important to investigate them from various points of view. As a result, in this study, we introduced two new points of view for investigating inadequate multiple account users:

- the number of user accounts for submitting questions and manipulating evaluations of their answers.
- the deviations of answer submission order.

Then, we investigated users in the data of Yahoo! chiebukuro from these points of view and found that

- the introduced points of view were useful for detecting inadequate multiple account users precisely,
- there were few users who did TYPE QA submission and TYPE AA submission at the same time, and
- some users might use multiple user accounts for purposes other than evaluation manipulation.

We intend to use the results of this study for further investigation of purposes and behaviors of inadequate multiple account users in Q&A sites. Especially, we intend to avoid unnecessary frictions between users in Q&A sites by detecting and taking care of these inadequate users.

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