A Discussion System for Knowledge Sharing and Collaborative Analysis of Incidents in Nuclear Power Plants

Saizo Aoyagi[1], Hidenori Fujino[2], Hirotake Ishii[1], Hiroshi Shimoda[1]
Hiroshi Sakuda[3], Hidekazu Yoshikawa[4], and Toshio Sugiman[5]

[1] Graduate School of Energy Science, Kyoto University,
Gokasho, Uji, Kyoto 611-0011, Japan
{aoyagi, hirotake, shimoda}@uji.energy.kyoto-u.ac.jp
[2] Safety Research Institute, West Japan Railway Company
1-2 -2 Matsuzaki, Abeno, Osaka, Japan
hidenori-fujino@westjr.co.jp
[3] Institute of Nuclear Safety System, incorporated
64 Sata, Mihama-cho, Mikata-gun, Fukui 919-1205, Japan
sakuda@inss.co.jp
[4] College of Nuclear Science and Technology, Harbin Engineering University, Harbin,
Heilongjiang, 150001, China
yosikawa@kib.biglobe.ne.jp
[5] Graduate School of Human and Environmental studies, Kyoto University, Yoshida-
nihonmatsu-cho, Sakyo-ku, Kyoto 606-8501, Japan
sugiman@toshio.mbox.media.kyoto-u.ac.jp

Abstract. Incident analysis is an important activity to maintain the safety of nuclear power plants. Much discussion is required to utilize the collected incidents effectively in the incident analysis activity. On-line Computer Mediated Communication(CMC) activity is an appropriate circumstance for geographically dispersed workers in nuclear power plants to discuss about the incident analysis. Some studies, however, indicate that the discussion activity in CMC tends to stagnate after a short period of time. For this study, the authors developed a discussion system for knowledge sharing and collaborative analysis of incidents, and proposed a method to promote discussion among users through introduction of "Active Participant". The Active Participant always behaves actively, and such behaviors are expected to promote the other members' incident analysis in the discussion group. To evaluate the effectiveness of the introduction of the Active Participant and obtain concrete guidance of the Active Participant, an experiment was conducted with nuclear power plant workers who were asked to evaluate the discussion system. The results of the experiment show that Active Participant can promote discussion among group members if enough number of incidents are submitted to the discussion system.

Keywords: knowledge sharing, incidents analysis, online discussion and promotion of discussion.

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Hiroshi Sakuda3, Hidekazu Yoshikawa4, and Toshio Sugiman5

1   Introduction

Incident analysis activity is a kind of efforts for prevention of accidents in safety-critical domain in which there are many dangers, such as medical workplace, building industries, nuclear power plants. Incident analysis is a procedure for collecting, analyzing and utilizing cases of incidents in which a danger was removed before accident occurs, or there was no damage by chance despite oversight of danger for safety[1], [2], [3].

For effective incident analysis activity, many cases of incidents must be collected. In addition to that, active discussion which triggers utilization of the collected cases is required in order to extract useful lessons for accident prevention by analyzing a case from diverse points of view, and application of these lessons. Japanese electric companies nowadays have made company-wide efforts to collected cases of incidents, and many cases are continuously collected. However, all collected cases are not always discussed sufficiently and utilized effectively.

The purpose of this study is to propose a method to promote discussion among workers for effective incident analysis.

2   Proposal of a Method for Promoting Discussion among Workers

The authors developed a discussion system for knowledge sharing and collaborative analysis of incidents which provides Asynchronous Computer Mediated Communication(CMC) environment as an effective way of incident analysis activity. Moreover, the authors designed a behavior guideline for active participants who are the special participants expected to activate the discussion among the group workers.

2.1   Discussion system for knowledge sharing and collaborative analysis of incidents

The discussion system is a Internet-based incident sharing tool which consists of Incident Sharing Page, Incident Registering Page, Electronic Bulletin Board and others. The user can submit incident information on the Incident Registering Page according to a framework of Root Cause Analysis as shown in Fig. 1[4]. All users can refer the submitted incidents on the Incident Sharing Page. Moreover, the users can discuss about the incident on the Electronic Bulletin Board which is prepared for each submitted incident

2.2   Active Participant

Some studies for education or knowledge management indicate that the discussion activity in CMC tends to stagnate. In particular, because workers in nuclear power plants are very busy, even if the discussion system can solve a problem that the
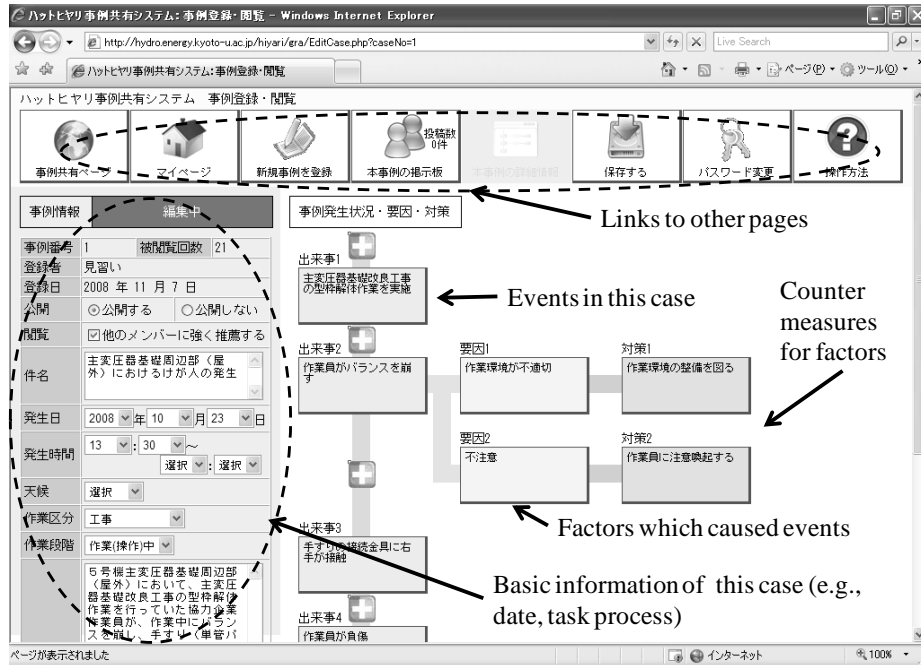
Fig. 1. Incident Registering Page of the discussion system.

workers are geographically separated, psychological resistance to participation still exists and stagnation of discussion occurs.

Some studies of social psychology indicate that human conforms to others' action in group activity when some members of the group show consistent action[5]. Applying this conforming behavior, introduction of "Active Participant (AP)" is proposed in this study as a way for promoting CMC discussion of incidents analysis. AP shows consistently active behavior in group incidents analysis, and this behavior indirectly promotes actions of other members of the group through their conforming to the AP. In addition to this indirect way, applying knowledge of educational studies[6] the AP implements direct intervention to discussion of incidents analysis, such as questioning to other members.

3   Experimental Method

In order to evaluate the effectiveness of the introduction of AP and obtain more concrete action guideline for AP, an experiment was conducted in which workers in nuclear power plants join incidents analysis activity using the developed discussion system.

Thirty workers who are task managers in Japanese nuclear power plants and six APs who are nuclear safety researchers having experience of working at nuclear power plants joined the experiment. The participants were divided into six groups

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which consist of five normal participants from three different plants and one AP. The division was made based on the machines which they have charge of in their daily work. The participants were explained that the purpose of the experiment is to evaluate the developed discussion system, and were requested to (1) evaluate the discussion system in a group of about five workers, (2) access to the discussion system every two days and above, (3) submit at least five incidents which was actually occurred or imaginary cases and (4) actively post messages in bulletin boards of the discussion system to discuss about the incidents with group members. APs were requested to (1) behave actively to show the way to other participant, and (2) activate discussion by asking many questions to other participant with a favorable comment.

Before starting the experiment, twenty two incidents were submitted by the experimenter to the discussion system. The experimental period was from January 13th, 2009 to February 6th (25 days). All participants received a gift which worths ten thousand Japanese yen after the experiment.

Basic information and psychological factors which probably affect the participant's behavior in the discussion activity were measured using achievement motivation scale and interpersonal orientation scale before the experiment. In the experimental period, action log, submitted incidents, and posted messages were collected. In addition, impressions towards other members' behavior in the group were questioned by web-based questionnaire after the experiment.

4   Results and Discussion

4.1   Activity trends of each group

Fig. 2 shows the accumulated total number of cases submitted and opened by all participants of each group(open cases). Fig .3 shows the accumulated total number of messages posted to the bulletin boards by each group.

In the first week (from day 1 to day 7), group 1, 2 and 5 submitted several cases and group 1 posted a few messages. In the second week (from day 8 to day 14), group 1 shows few activity, and group 2, 5 and 3 submitted many cases and posted many messages. Group 4 and 6 submitted a few cases. In the third week(from day 15 to day 21), group 2, 3, 4 and 5 increased cases and messages. In the last 4 days(from day 22 to day 25), group 2 and 3 submitted many cases and posted many messages.

These figures show that each group activity did not show equivalent patterns. Six groups can be categorized into three patterns of activity. First pattern, which group 1 and 6 show, is a stagnating pattern. In these groups (stagnating groups), few cases had been submitted, and few messages had been posted. Second pattern, which group 2 and 5 show, is an activated pattern. In these groups (activated groups), the activity was very active throughout the experimental period by submitting many cases and posting many messages. The total number of actions of the activated groups was twice as many as that of the stagnating groups.
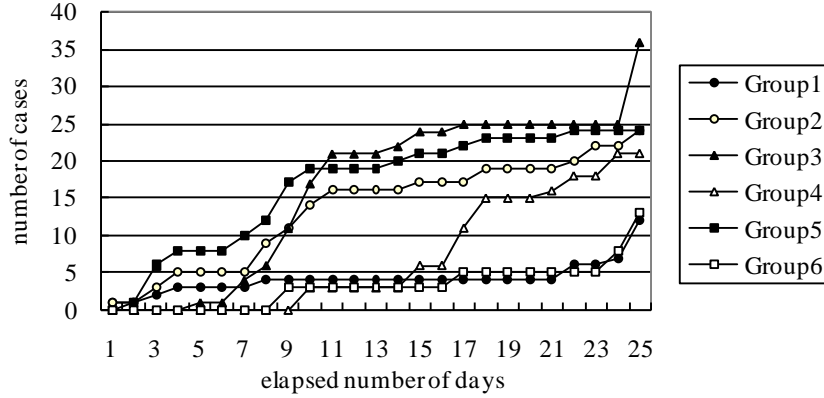
Fig. 2. Accumulated total number of open cases of each group.
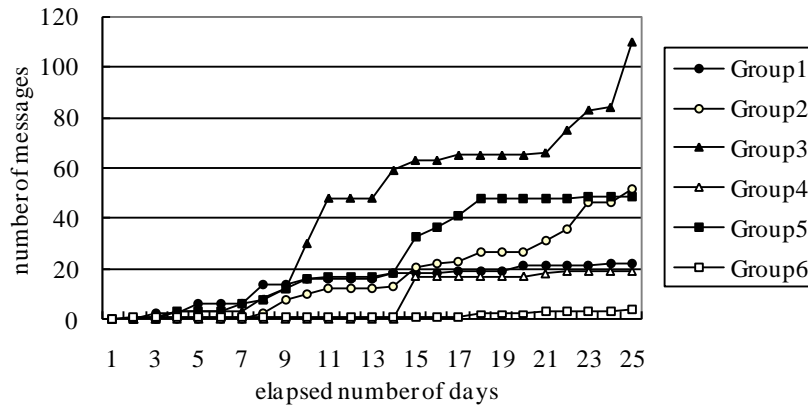
Fig. 3. Accumulated total number of messages in bulletin boards of each group.

Third pattern, which group 3 and 4 show, is a middle pattern. In these groups (middle groups), a stagnating trend appears at the beginning. Nevertheless, they were activated after the middle of the experimental period and outweigh some groups.

4.2   Activity trends of active participants

The result of the experiment shows that the normal participants' activity does not have much correlation with AP's activity. In this experiment, all APs did not submit many cases. APs of group 1, 2, 3, and 5 posted many messages, and APs of group 4 and 6 didn't post many messages. However, AP of group 5 posted messages after normal participants had done. Therefore activation of group 5 was caused by the AP at least on the beggining. Consequently, there may be the other factors which activate the

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Hiroshi Sakuda3, Hidekazu Yoshikawa4, and Toshio Sugiman5

groups besides the AP's behavior. Next, detailed results of three patterns are discussed to clarify cause of such difference of activity in the experimental period.

4.3   Activated groups

A comparison of Fig. 2 and Fig. 3 shows that the posted messages increased after the submitted cases increases in the activated groups (group 2 and 5). In the first week, a few cases were submitted but any messages were not posted. In the second week, a few messages were posted which are related to the cases submitted in the first week. Then, many cases were submitted around day 8. After about a week, many messages were posted.

These facts indicate that increasing of new cases promote posting messages. The reason of these phenomena will be discussed later.

4.4   Stagnating groups

Fig. 4 and Fig. 5 show accumulated total number of open cases and messages of group 1. The participants were requested to submit at least 5 cases, but two participants in the group 1 submitted no cases. The AP in the group 1 also did not submit any cases. This group shows stagnating trend especially in the middle of the experimental period. During this period, anyone submitted no cases and only one message was posted in day 17 except the messages by the AP, in spite that the AP posted messages continuously. Such stagnation was also observed in group 6. However, differently from the group 6, the messages posted by the AP in the group 6 were not ignored completely. The activity in the group 1 stagnated in spite that there were some replies to the AP's messages and a few messages between two normal participants were exchanged.
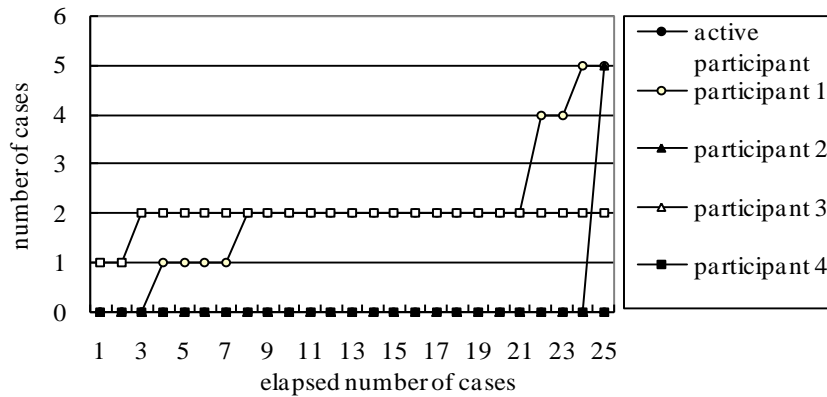

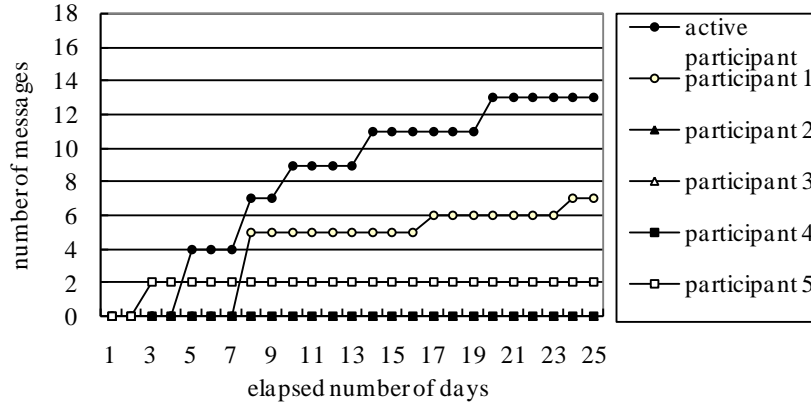**Fig. 4.** Accumulated total number of open cases of group 1.

Fig. 5. Accumulated total number of messages in bulletin boards of group 1.

4.5   Middle groups

Fig. 6 and Fig. 7 show accumulated total number of open cases and messages of
group 4. The group 4 is one of the middle groups which were activated in the middle
of the experiment. Although there were no submitted cases or posted messages at the
beginning, a sudden activation was occurred in day 15. Some cases and messages
were suddenly inputted in day 15, followed by posting a few messages and submitting
some cases during the period between day 16 and 25. Group 3 also experienced a
sudden activation during the period between day 8 and day 10. In the group 3, the
cases and messages increased continuously and reached at the largest number among
all groups at the end. On the other hand, a few cases and messages were inputted at
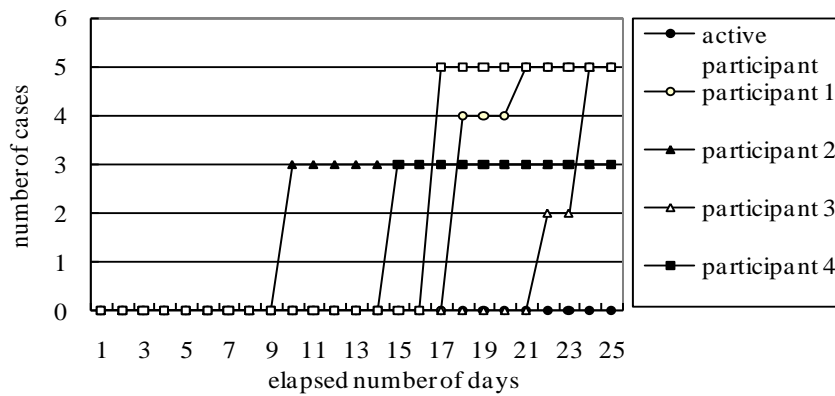the end of the experiment in the group 4.

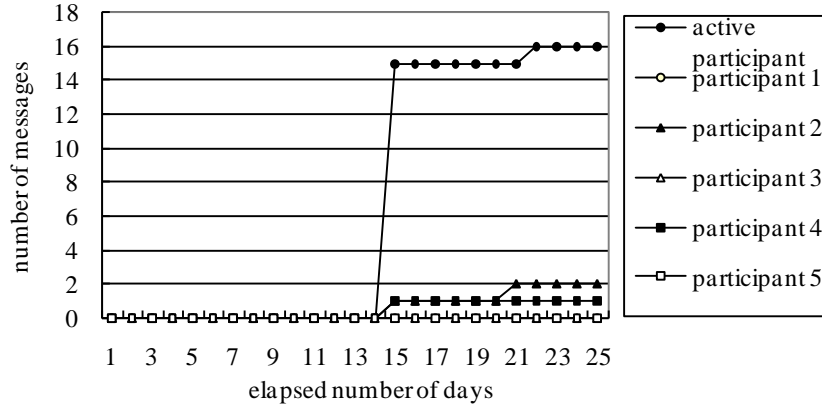**Fig. 6.** Accumulated total number of open cases of group 4.

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Hiroshi Sakuda3, Hidekazu Yoshikawa4, and Toshio Sugiman5

Fig. 7. Accumulated total number of messages in bulletin boards of group 4.

4.6   Analysis of middle groups' activation

We pay attention to the sudden activation of group 3 and group 4. Fig. 8 shows action time-line chart of group 4 in day 15. Vertical axis of this chart is time, and each action is arranged by participant. The arrows represents that the end point case is a target of an action such as viewing cases or posting messages.

Fig.8 shows that the first action in day 15 was AP's post of fifteen messages. After that, the participant 4 viewed some cases which the AP posted some messages to. Then, the participant 4 submitted three cases and posted one message to case 25, which was submitted by the participant 2 in day 2. This message was replied by the participant 3 in the afternoon. After that, the participant 4 thanked the participant 3 for the reply using "evaluate button" which is a special function of the bulletin board of the discussion system. The last action in day 15 was viewing cases by the participant 1.

Although Fig. 8 has no information about participant's intention and causal relationships of actions, the AP probably triggered other members' actions. That is because the other participants hadn't submitted any cases and posted any messages before the AP posted some messages. Similarly, AP triggered other members' action in other group. Sudden activation of group 3 between day 10 and day 8 seem to be triggered by AP's posting one message in day 3.
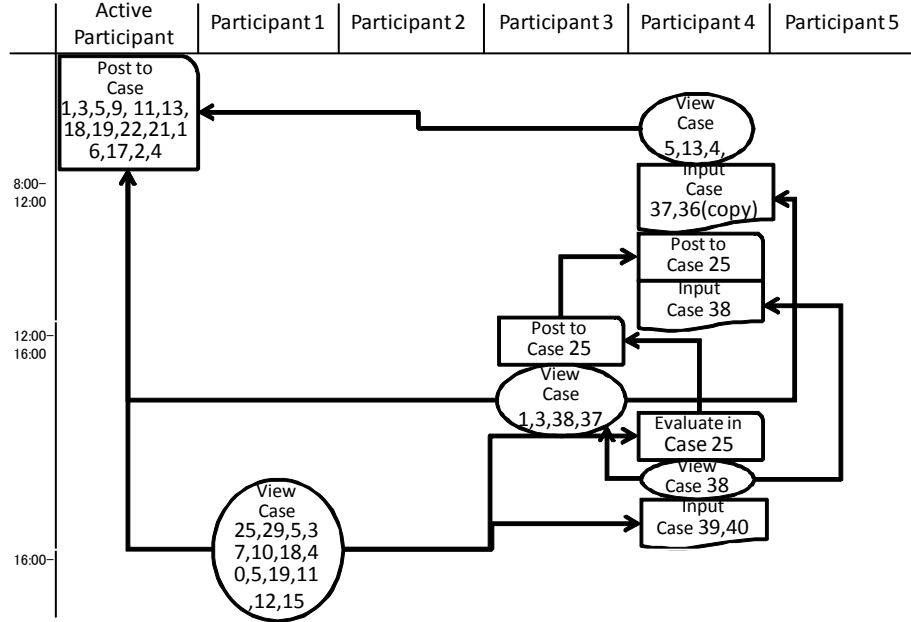
Fig. 8. Action timeline chart of group 4 in day 15.

5   Conclusion

The results of the experiment indicate that AP could promote discussion activity through triggering other members' actions in the middle groups. Nevertheless, even if the AP was active as mentioned in 4.2, the activity of group 1 stagnated in the middle of the experimental period. To explain this difference of APs' effectiveness, we pay attention to the difference in number of submitted cases of group 3, group 4 and group 1. When the discussion was activated, many cases were submitted by participants in group 3 and group 4. On the contrary, few cases were submitted in group 1.

One interpretation of these facts is that submitting new cases is required for activation of discussion in bulletin boards. The fact that posted messages increased after submitted new cases increases in activated groups, as mentioned in 4.4, also supports this interpretation. This is probably because a new case provides a topic for discussion.

Moreover, this interpretation implies that cases which the experimenter had submitted before the experiment were inappropriate as a topic of discussion. This is probably because pregnant topics are needed for discussion. These are cases of general incidents in nuclear plants and are not about special domain or machines. Therefore these cases are not so worth because of lack of professional implication. Another probable reason of why new case is needed is responsibility to answer the question. If a participant has a question to a case, he will ask about the case to other participant who submitted the case. This is because the participant who submitted the

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case should know the background of the case. However, if the case was submitted by the experimenter, any participants don't know all about the case. The only option is asking about the case without specifying who should answer this question. However anyone have no responsibility to answer and could not answer such a question. Therefore, the question will be left without answered. This is the cause of the stagnation of the discussion. Therefore, not experimenter but participants and AP have to submit cases for the promotion of discussion.

Therefore, if APs submit many proper cases, and post messages, discussion activity of other members is expected to be activated. The AP of group 1 should have submitted cases of incidents for providing new topics, in the middle of the experimental period. However, in this experiment, the APs were not workers of nuclear power plants, but researchers in the area of safety management. Consequently, because they have much other task to do, and don't have occasion of experience of incidents in nuclear power plants, they could not submit cases frequently. Therefore, AP should be selected from nuclear power plant workers, or someone who has proficient knowledge about incidents.

In this article, we proposed a method to promote discussion activity in a discussion system for knowledge sharing and collaborative analysis for incidents analysis which is effective to maintain safety of nuclear power plants, and the evaluation experiment was conducted.

However, not all results of the experiment were analyzed. In particular, only qualitative data of the results are analyzed. In the future, contents of cases and messages and ex-post questionnaire will be analyzed in qualitative way in order to verify the implication discussed in this article. Moreover, interview survey will be conducted, to collect evidences which support our hypotheses.

6   References

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