Analysis of Team Communication Characteristics Using SNA Technique

Ar Ryum Kim [a*], Jin Kyun Park [b], Seung Woo Lee [a], Hyun Gook Kang [a, c], and Poong Hyun Seong [a]
[a] *Department of Nuclear and Quantum Engineering, KAIST, 373-1, Guseong-dong, Yuseong-gu, Daejeon, Korea*
[b] *Integrated Safety Assessment Division, KAERI, Daeduk-daero 9889-111, Dukjin-dong, Yuseong-gu, Daejeon, Korea*
[c] *Khalifa University of Science, Technology & Research, P.O. Box 127788, Abu Dhabi, UAE*
[*] *Corresponding author:phseong@kaist.ac.kr*

1. Introduction

An important aspect of human behavior in nuclear power plants (NPPs) is team interaction since operating NPPs involves the coordination of several team members among and within workplaces. In this environment, operators in NPPs communicate with each other to share situational information. Unfortunately, inappropriate communication can cause a lack of situational information and lead to serious consequences of systems [1-2]. This implies that it is requisite to study the communication characteristics of operating team to secure the safety of NPPs.

Many researchers have endeavored to investigate the characteristics of team communications. However, previous studies seem to characterize team communications based on a single perspective such as communication contents as well as communication structure [3].

In this regard, it seems that social network analysis (SNA) would be a comprehensive method which enables analysts to characterize team communications from both perspectives. In this study, a density score which is one of the communication characteristics was obtained by using SNA. Moreover, the ratio of inappropriate communications was calculated using the taxonomy for inappropriate communication [4]. Finally, the communication characteristic distinguished by the density score is compared with the ratio of inappropriate communications to extract meaningful insights which could contribute to prevent the occurrence of inappropriate communications.

2. Application of SNA to understand communication characteristics of operating teams in NPPs

Social network is defined as a specific set of linkages among a defined set of persons, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behavior of the persons involved [5]. The purpose of SNA is to provide insightful information and inferences on the organization and structural properties of a network, given its nodes and relations [6].

There were efforts to understand communication characteristics using SNA, which used questionnaire to collect input data for SNA [7]. However, using questionnaire can cause a problem of subjectivity of the results.

In this study, a speech act coding scheme [8] is adopted to collect input data for SNA in more objective way. After collecting input data, the density score which is defined as the overall level of interaction among team members, analogous to the mean number of ties between them, is obtained using *Eq. (1)* [9]. It should be noted that, for this reason, the density score has been frequently used to determine the degree of cohesiveness which is one of the important characteristics representing team communications [7].

$$Density = \frac{the\ total\ number\ of\ ties}{the\ total\ number\ of\ the\ possible\ ties} \quad (1)$$

3. Taxonomy of inappropriate communications

Many researchers have developed various kinds of taxonomies to identify inappropriate communications for the purpose of reducing the occurrence of inappropriate communications. In this study, the taxonomy shown in Table I was adopted from Ref. [4] in order to identify inappropriate communications from verbal protocol data. After that, the ratio of inappropriate communications was calculated.

Table Ⅰ: Taxonomy of inappropriate communication

Types of inappropriate communication	Description
Slip	These are errors in content, which are often described as 'slips of the tongue'.
No readback	There are failures by pseudo-pilots to readback instructions.
No response	Cases where a communication does not receive a response.
Contradict previous instruction	Controller issues an instruction which contradicts one previously communicated.
Query	A controller or pilot asks a question which demonstrates that they have not understood or forgotten a key piece of information.
Context required	There are cases where some form of problem is being discussed or implied, but further context is required on the operational events associated with the problem.
Use of own language	Use of other language than English for instructions.
Change of plan	These are cases where a controller has stated or begins to state a message but then modifies it straight away.

Break	Controller use of the term 'break'
Station calling	Specific query which indicates that a controller has missed a communication by a pilot.
Expedite	Use of the term 'expedite'

4. Case study

To perform the case study, verbal protocol data which are audio-visual recorded under abnormal training sessions by MCR operating teams are used [10]. Total amount of team communications for the each team is 291 and 278, respectively. First, the density score of each team is calculated using Eq. (1). Second, the ratio of inappropriate communications for each team is calculated using the taxonomy summarized in Table I. Table II shows the results of these calculations.

Table Ⅱ: Density and the ratio of inappropriate communications

Types of inappropriate communication	Team 1 (Density: 0.67)	Team 2 (Density: 1.90)
Slip	3.09%	1.08%
No readback	2.41%	3.6%
No response	18.9%	14.39%
Contradict previous instruction	0%	0.04%
Query	5.84%	3.6%
Context required	24.05%	1.8%
Use of own language	0%	0%
Change of plan	0.07%	1.44%
Break	0.03%	0%
Station calling	0%	0%
Expedite	0%	0%

5. Discussion and conclusion

As stated at the end of Section 2, the density score can be used to determine the degree of cohesiveness which is one of the important characteristics representing team communication. Thus, it is possible to expect that a team of which the density score is high would have tendency to communicate more frequently with team members resulting in more cohesive communication.

As shown in Table II, the density score of Team 2 is higher than that of Team 1. This indicates that team members belonging to Team 2 are more cohesive with each other than those of Team 1. In this regard, it is interesting to note that team members belonging to Team 2 showed the lower ratio of inappropriate communications except 'No readback' and 'Change of plan'. In addition, the ratios of 'Context required' between two teams are quite different. The observations implied that the possibility of inappropriate communications will decrease when team members are more cohesive with each other because frequent communications enable team members to achieve a greater degree of coordination, as well as information sharing. It is evident that this insight is still questionable because it was extracted from a limited number of verbal protocol data. However, since the ratio of inappropriate communications between two teams are quite difference with respect to the associated density scores, it is reasonable to conclude that the use of SNA techniques could be useful to extract meaningful insights that are able to contribute the reduction of inappropriate team communications.

REFERENCES

[1] C.E Billing and R. L. Grayson, The Information Transfer Problem: Summary and Comments, In: Information Transfer Problems in the Aviation System, N81-31166, 1981

[2] P. Shanahan, D. Gregory, M. Shannon, and H. Gibson, The Role of Communication Errors in Railway Incident Causation, In: People and Rail Systems-Human Factors at the Heart of the Railway, Ashgate, 2007

[3] J.K. Park, The Use of a Social Network Analysis Technique to Investigate the Characteristics of Crew Communications in Nuclear Power Plants-A Feasibility Study, Reliability Engineering and System Safety, 2011

[4] B. Kirwan, W. H. Gibson, and B. Hickling, Human Error Data Collection as a Precursor to the Development of a Human Reliability Assessment Capability in Air Traffic Management, Reliability Engineering and System Safety, Vol. 93, pp. 217-233, 2008

[5] J.C. Mitchell, Social Networks in Urban Situations, University of Manchester Press, 1969.

[6] Cioffi-Revilla C. et al., Computational Analysis in US Foreign and Defense Policy, The first international conference on computational cultural dynamics, 2007

[7] K. Henttonen, Exploring Social Networks on the Team Level-A Review of the Empirical Literature, Journal of Engineering and Technology Management, Vol. 27, No. 1-2, 2010

[8] S. H, Kim, J. K. Park, S. Y. Han, and H. J. Kim, Development of Extended Speech Act Coding Scheme to Observe Communication Characteristics of Human Operators of Nuclear Power Plants under Abnormal Conditions, Journal of Loss Prevention in the Process Industries, Vol. 23, pp. 539-548, 2010

[9] R.A.J. Leender et al., Virtuality, Communication, and New Product Team Creativity: A Social Network Perspective, J. Eng. Technol. Manage., Vo. 20, No. 1-2, 2003

[10] J.K. Park et al., Analysis of communication contents and associated crew performance data collected from abnormal operating conditions of nuclear power plants, KAERI/TR-4159/2010, 2010