Hybrid Communication Model: Project Risk Analysis of IS Development by using Multi-agent Simulation Technique

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Abstract. The success rates of information system development projects are generally extremely low. These rates are often attributed to the characteristics of the project deliverables and the processes involved in their development. Previous studies on the subject have stated that the main cause of problems in these projects is related to the participants, namely, the project stakeholders. Nevertheless, most research in risk management has focused on project processes without attending to the individual participants. Furthermore, many of these studies have used static analysis procedures that draw on knowledge from past projects. In such conditions, Yokota and Seki (2015) have proposed multi-agent simulation models that provide dynamic analysis of the behaviors of project participants that often pose serious risks to information system development projects. This study discusses the role and necessity of the code model and the inferential model in project communication model and proposes an advanced model for project communication that combines the Shannon-Weaver model with a model from the relevance theory of communication. To perform simulation experiments based on the proposed model, the metrics to evaluate the maturity levels of the environment for inference and communication rule set is proposed.

Keywords: Communication Model, Shannon-Weaver Model, Relevance Theory, MAS

1. INTRODUCTION

CHAOS (2013) recently reported that the success rate of information system development projects is 39%. This rate is extremely low when compared to analogous projects in other fields. For example, projects in the construction and pharmaceutical industries have higher success rates. There are many reasons for the failure of information system development projects. While analyzing the causes of failure, sometimes referred to as lessons learned, poor project management skills have often been indicated as a cause without verification. However, differences of opinion among project members and sudden changes in customer specifications are known to be the major causes of the failure of information system development projects (e.g., Khan *et al.* 2014).

In information system development projects, significant risks often originate from the behaviors of the stakeholders. Many risk management studies have employed statistical approaches that examine stakeholder behavior to improve the success rates of information system development projects. A few studies have also attempted to use simulation techniques, such as multi-agent simulation, to analyze the behavior of information system development projects and/or project stakeholders.

Agarwal and Umphress (2010) showed that simulations could aid project managers and process engineers in making changes to planned development processes. In their example, simulation techniques were used to evaluate the project team and individual performances. The Monte Carlo simulation is also often employed to quantify project risk, where cost and time are used as stochastic variables. These simulation techniques forecast the cost and the required time for project completion and attempt to check the validity and feasibility of the project implementation aspect of risks originating from stakeholders' attitude and behavior. This approach simulates the capability of the project team members, but does not consider interaction among members.

Wickenberg and Davidsson (2003) split the simulation methods for software development processes into two categories, namely, the activity-based approach and the individual-based approach. The activity-based approach focuses on the productivity rate of each activity in software development processes, whereas the individual-based approach focuses on each developer's approach to software development as well as interactions among developers. They also suggest that the individual-based approach and multi-agent simulations are fundamentally similar approach. While the use of both activity-based approach and individual-based approach is possible, only one of these approaches is used in most cases while simulating a real-world scenario.

The success of a project is related to the behavior of the stakeholders, such as the project manager, the project members, and the client, especially in information system development projects. Therefore, the behavior of project stakeholders is important to be analyzed to predict the cause of disturbance in the progress of the project and the whole behavior of the project team activities and other stakeholders. The individual-based approach can encompass both the individual and interactions among individuals through the employment of a multi-agent simulation to analyze these problems.

In this study, the project communication model for information system development projects proposed by Yokota and Seki (2015a, b) is refined for real-world project communication by introducing the previous result of communication studies in linguistics: e.g., Sperber and Wilson 1995) and Grice (1961, 1989).

2. REFINING THE COMMUNICATION MODEL

Project communication is one of the project activities that contain a mechanism for concise and exact communication among various stakeholders. This mechanism is roughly classified into two types of communication, namely, horizontal and vertical communication within a project team and communication between a project team and an external organization. In this context, an external organization is defined as the project owner and every stakeholder of the customer's organization.

The scope of this study excludes the subject of consensus-building e.g., the perfect consensus-building of the objective goal between the project manager and each his/her member, but includes the halfway project communication process that will only confirm the completion of exact information transmission. Under this assumption, in practice, most activities in project communication are often represented through a combination of the one-to-one communication model proposed by Yokota and Seki (2015a, b).

This scenario allows a strong constraint on the purposes of this study such that the communication models proposed in this study should represent the information transmission and reception between the sender and the receiver. One of the basis of project management is iterative consensus-building among stakeholders. Hence, the previous presumption causes some inconvenience in describing a project communication model. Generally, even if perfect information transmission and reception are realized without consensus, the sender and the receiver continue the exchange of query and answer with modified information content to achieve a consensus until the completion of consensus-building. Furthermore, in the case of multiple participants, the operation of information exchange is repeatedly performed until a consensus is reached. Examples of these scenarios are shown in Figures 1, 2, 3, and 4.

For example, Figure 1 shows that information is sent by sender A and received by receiver B. This model expresses the assumption of this study regarding project communication models where two-way communication is expressed by doubly

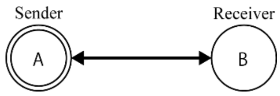

Figure 1: One-to-one communication

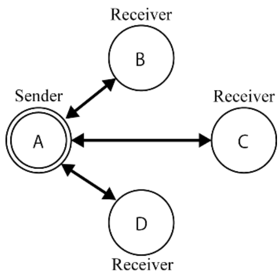

Figure 2: One-to-many communication

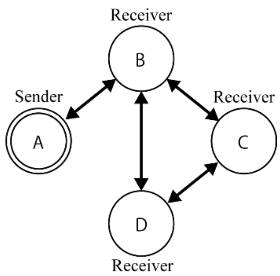

Figure 3: One-to-one + one-to-many communication

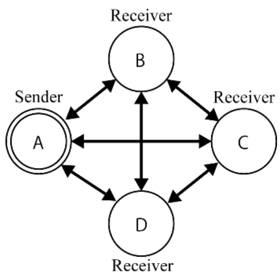

Figure 4: One-to-many + many-to-many communication

using one-way communication model. In case the information sent by A cannot be accepted by B, B sends its objection and proposed amendment to the information to A. This information exchange is repeated until a consensus is obtained between A and B. In this simple model, each iteration supports the assumption of this study as shown in the models presented in Figures 2, 3, and 4.

Information exchange in project communication can be expressed using very simple models, but a complete and accurate project communication model should include a mechanism for arriving at a consensus. Otherwise, the model cannot stop the iteration in project communication.

Many previous studies have discussed consensus-building problems in general and provided a few cases of project implementation (e.g., Mitome et al., 2007). However, the accurate model for these scenarios is very complex, and the scope, field, and/or situations comprising these discussions are very diverse, each being limited in its own way. Accordingly, given that the discussion of information transmission and consensus-building can be separated, it is useful not to address them simultaneously. In this study, a project communication model without a consensus-building mechanism is considered. In the following discussion, a one-to-one unidirectional communication model is discussed, but this constraint does not impose any limits on the project communication.

For example, Osgood (1957), Schramm (1954), and DeFleur (1966) have provided a general and typical communication model related to the code model. The concept underlying each communication model is not identical, but certain basic structures are represented by the Shannon's model (Shannon, 1948). As shown in Figure 5, the Shannon's model is composed of the following components: the encoder in transmitter, the decoder in receiver, and the impact of noise. Figure 5 is a well-known structure of information communication in telecommunication.

In this model, the information source is generated and sent to the destination by the sender. The information is encoded by a transmitter and decoded by a receiver. During the transmission process, the information sometimes includes noise and might be incomplete. Shannon's model is reconsidered in the context of communication among persons by Weaver, and the result is summarized by Shannon and Weaver (1949).

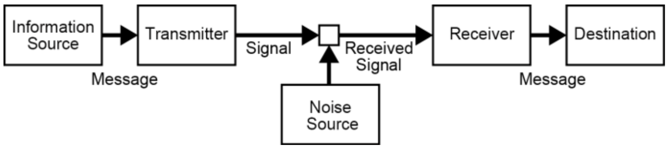

Figure 5: The Shannon-Weaver model (Shannon and Weaver, 1949)

The Shannon-Weaver model (Shannon and Weaver, 1949) is often criticized by researchers in human communication and its management because verbal communication between persons is not accurate similar to communication between machines. The difference of rule sets for communication between the transmitter and the receiver cannot be neglected and is unstable. In the case of information communication between machines, the rule set usually coincides with the machines by mechanical or electronic adjustment. On the contrary, in the case of a project, although it is difficult to realize a complete coincidence of rule sets with participants, most organizations try to improve the degree of completeness of rule set coincidence; hence, they propose and improve their unified organization rule set for the exact project communication. Figure 6 shows the model of this trial embedded by the organization to the original Shannon-Weaver model.

In Figure 6, the common rule for the speaker's encoding process and the receiver's decoding process is improved by higher maturity levels of project management, especially project communication management. On the other hand, lower maturity levels exacerbate the difference in code between the speaker and the receiver, which is expressed by noise in the figure.

To embed more characteristics of project communication in the proposed model, an idea from the relevance theory is introduced, which states that the informative intention: *to inform the audience of something*, and communicative intention: *to inform the audience of one's informative intention* (cf., Sperber and Wilson, 1995). In project communication management, a rule set should be made for the speaker in a project to declare the informative intention, the communicative intention, and other required regulations to avoid communication misunderstanding. This rule set enhances the speaker's communication skills. Higher maturity levels of project communication management lead to higher levels of

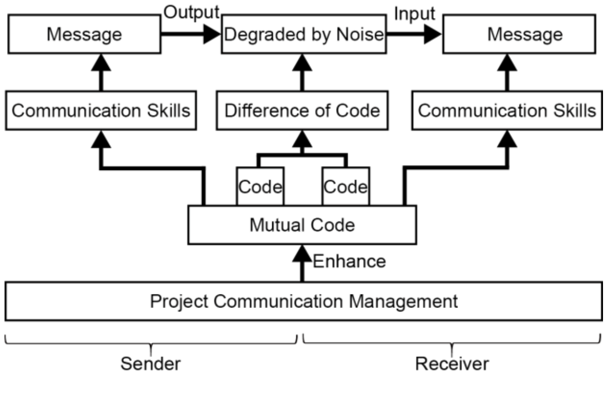

Figure 6: Code model extension for project communication

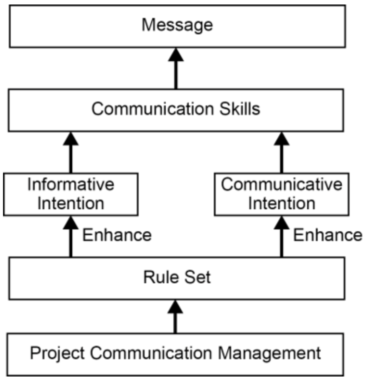

Figure 7: Communication accuracy based on rule set

clarity in informative intention and communicative intention. Figure 7 shows this mechanism.

According to relevance theory, the richness of the speaker's experiences lends concreteness to the content of the message and enhances the understanding of the intention to the receiver. Furthermore, the richness of the receiver's experiences enhances the inference that can be drawn from the content of the message of the speaker. Moreover, the richness of the mutual cognitive environment (cf., Sperber and Wilson, 1995) that is based on common experiences between the speaker and the receiver provides an environment for a good understanding of the message to the receiver. On the other hand, poor mutual cognitive environment for the receiver often leads the failure of communication, which is shown in Figure 8.

Mutual cognitive environment consists of mutual experience in project, cultural, and other project-related activities. This is enhanced by sharing the project environment and cultural experiences required for the implementation of the project to improve mutual perception, which is shown in Figure 9.

Furthermore, Figure 10 shows the intention of the speaker and his/her inference in the context of the relevance theory as interrelated with project management activities. The

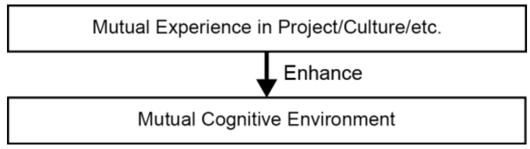

Figure 9: Mutual cognitive environment enhancement

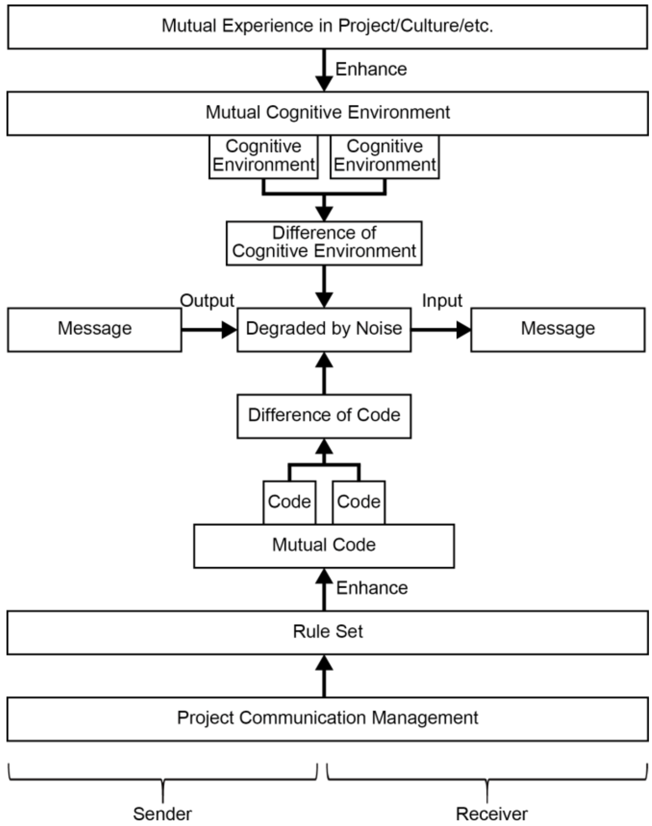

Figure 10: Degradation based on code difference

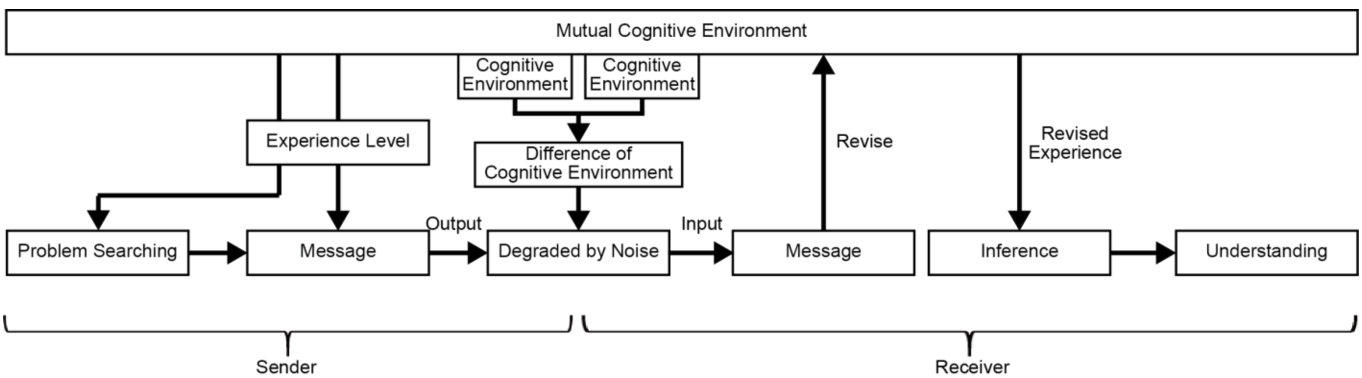

Figure 8: Mutual cognitive environment and Inference

differences of cognitive environment between the speaker and the receiver are introduced in defining the noise level.

In summary, Figure 11 shows a hybrid project communication model that fuses two thoughts pertaining communication, the Shannon-Weaver model and the relevance theory, and is optimized to information system development projects.

3. PARAMETERS FOR CHARACTERIZATION

3.1 Origin of Exact Communication

Sperber and Wilson (1995) provided widely known fundamentals for communication studies. In general, the communication model is divided broadly into two categories, namely, the code model (cf., e.g., Shannon and Weaver, 1946) and the inferential model (cf., e.g., Grice, 1961, 1989, and Lewis, 1969). Sperber and Wilson (1995) reported that a combined model based on these two categories cannot simultaneously accept a message at the same instance. However, the proposed model shown in Figure 11 is composed of these two basic communication models, which contradicts the general understanding of communication studies.

To obtain a useful understanding of the research in this study, it should be noted that the scope of Sperber's discussion is focused on the daily and general communication. That is, Sperber’s famous discussions are founded on a highly generalized environment.

In general, in case of a strong additional constraint that extends the discussion intended for information system development projects to Sperber’s advanced generalized environment, the characteristics of the environment of project communication can be summarized as follows:

A1) Most vendors independently employ a common communication protocol based on the code model as a rule of the relevant organization.

A2) The relationship between the vendor and its subcontractor is usually continuous, close, and inter-dependent. Therefore, the subcontractor often employs the vendor’s communication protocol.

A3) At sites of large-scale projects, multiple major vendors join as vendors or subcontractors and use different project communication protocols.

A4) The communication protocols between the vendor and the customer do not always coincide.

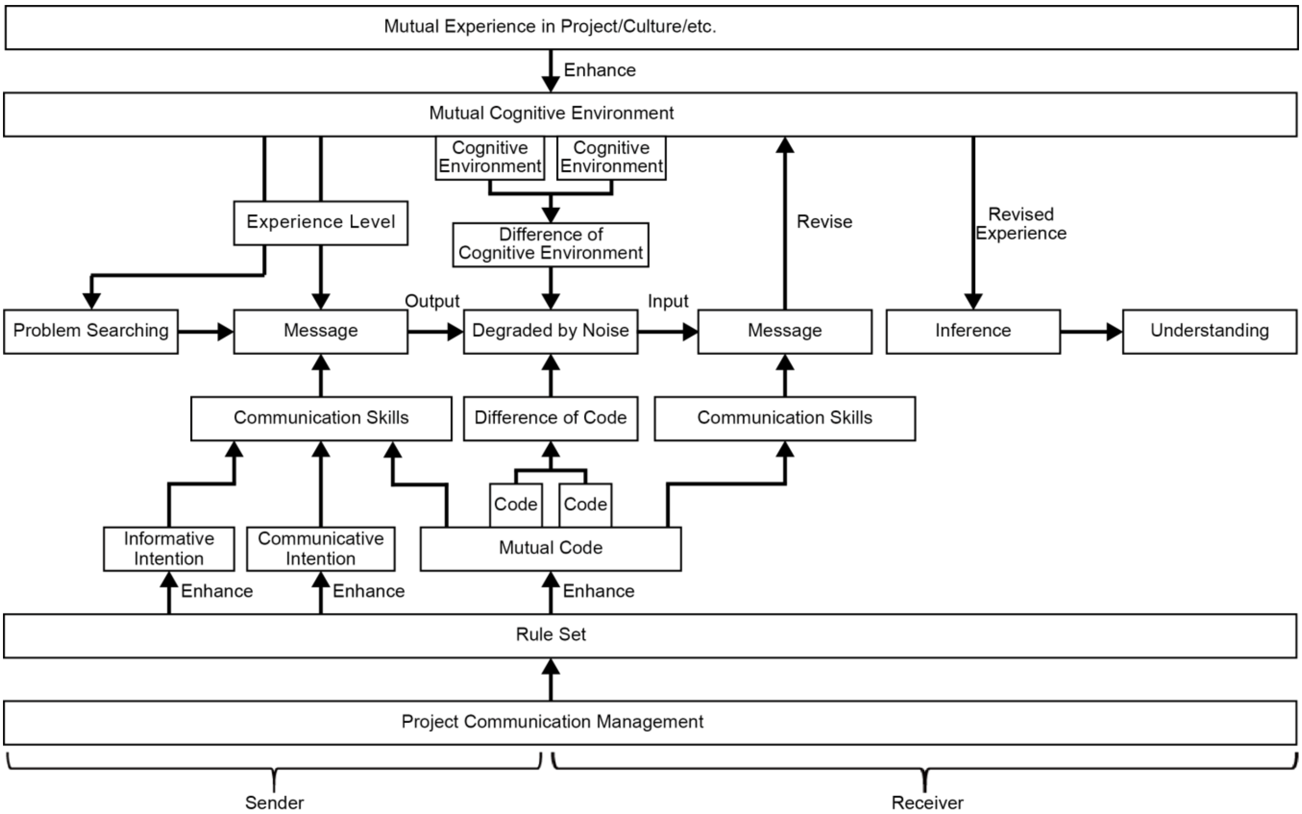

Figure 11: Hybrid Communication Model (proposed model overview)

A5) In every case mentioned previously, in issuing a project charter according to corporate level project management, the basic information concerning the project e.g., strategic goals, objective goals, preconditions, constraints, scope, and risks involved in the project, are common to all stakeholders.

Under the constraints and conditions mentioned previously, the elementary issues in the code model provided by Sperber should be resolved by formulating a more sophisticated rule set to represent an ultimate goal for project communication management. However, realizing a complete rule set and its complete implementation to all project participants maybe excessive. In the following sections of the paper, the difficulties of this approach are discussed and the necessity and validity of the proposed hybrid model are established.

In special environments, such as those involving project communication, non-verbal communication that can lead to ambiguity should be removed, and incomplete information dispatch needs to be controlled for successful project communication.

On the contrary, it is empirically understood that well-known issues in project communication cannot be expressed by only using the code model, which is confirmed in Grice's discussion (1961, 1989) that introduced eight contexts for general communication:

B1) Information about the immediate physical environment.
B2) Immediately preceding utterances.
B3) Expectations about the future.
B4) Scientific hypotheses.
B5) Religious beliefs.
B6) Anecdotal memories.
B7) General cultural assumptions.
B8) Beliefs about the mental state of the speaker.

These expressions (B1-B8) are quoted from Grice (1961, 1989).

In general, the set of contexts that arise in conversations are precondition set for understanding the meanings of conversations. Therefore, the accuracy of the receiver's understanding is related to the degree of match between the speaker and the receiver's contexts. Although Grice considers highly general communication, these considerations should be considered in general project communication. In particular, B3 to B7 should be considered as an integrity of the project manager's required competencies. Under the environment of recent virtual project communication supported by distance meeting systems, B1 becomes an important factor for successful project communication from a different understanding of Grice's original assumptions. However, situations B2 and B8 should be disregarded in project communication.

Despite being far from possibility in project communication, it is ideal that the receiver perfectly understands the speaker's intention without any precondition set for the speaker's context. Sperber's consideration of highly general environments indicates that the only way of guaranteeing that the receiver does not misunderstand requires achieving a normalized, perfect match between the receiver's actual context and the speaker's assumed context. However, it is not possible for the speaker to have access to the perfect precondition set of the receiver in common communication. The speaker assumes a partially shareable precondition set to the unknown speaker's context. This uncertain precondition set is called "common knowledge" and "mutual knowledge" by Lewis (1969) and Shiffer (1986), respectively. They claim that one condition for successful communication is that the assumptions of the speaker and the receiver regarding context must be common knowledge between them. In practical situations, if the speaker tries to confirm the receiver's assumed knowledge, a process of assumptions about a shareable precondition set is repeated. A replacement is then indicated in the receiver's assumed knowledge, with regard to the mutual assumption, having a probability that is a general concept for probabilistic phenomena. Even though the trials realize highly accurate mutual knowledge, there are some serious challenges that should be solved for successful communication, i.e., the recognition of the degree of probability in the assumptions of both the speaker and the receiver. Accordingly, it is well known that the condition by Sperber mentioned previously, e.g., the realization the condition for communication with perfect knowledge of receiver's context is not possible.

To accept an inference from the non-linguistic features of a conversational situation, Grice (1961, 1989) proposed a cooperative principle and four maxims of conversation, namely, quantity (information), quality (truth), relation (relevance), and manner (clarity). Each maxim has two, two, one, one, and four specific requirements, respectively. Grice's theory is applicable to project communication management because the maxims are understood as a strict rule set and encapsulate the goal of maturity for successful project communication. At the same time, it is easy to claim from experience that accepting the rule set is difficult in real project communication. Moreover, Grice provides the theory of conversational implicature. This theory indicates that even if all maxims are perfectly reflected in the conversational communication, some unsolved problems remained in the practice of successful project communication. This fact and other important considerations indicate an important aspect of project communication management practices, that is a complete rule set, which is often considered a goal of matured project communication management, is not always the best and final solution to successful project management. As mentioned previously, both models, the code model and the inference model, could not satisfy the requirement of successful project communication by the use of each approach alone. Therefore, the proposed hybrid structure composed of the code model and the inferential model should be employed to the project communication model to address the weak points of each model.

3.2 Set of Parameters

As discussed in Section 3.1, there are parameters in the hybrid communication model, which are shown in Figure 11, that determine the success rate of communication. The determinant factors of communication success rate are: the maturity level of enhancements of mutual cognitive environment in Figure 9 and the rule set in Figure 10. Although, for example in Yokota and Seki (2015a, b), there are some parameters concerning the accuracy of updates of the mutual cognitive environment that support the receiver's inference, the two parameters that relate to the communication infrastructure in the proposed model will be the focus of discussion.

The discussion in Section 3.1 shows that the complete acceptance and incorporation of the precondition set for content-based inference proposed in Grice's cooperative principle is not possible, at least under the general conditions and in usual project communication environments. On the other hand, as shown in the above discussion, although the highly generalized communication environments assumed in discussions by Sperber and Grice are difficult to realize, information system development projects can use their insights to achieve mature levels of communication.

Hence, the proposed model employs nine specific requirements expressed in eight contexts as degree of maturity levels of the mutual cognitive environment, the degree of probability of the mutual assumption, and four maxims for the degree of maturity level of the rule set.

In this study, the maturity levels of the mutual cognitive environment and the rule set are defined as follows;

Maturity Level of Mutual Cognitive Environment
= Average Score of Mutual Understandings for 8 Context
× Degree of Probability,

Maturity Level of Rule Set
= Average Score of Degree of Achievement Levels for 4 Maxims Requirements.

4. CONCLUSION

In this study, a project communication model for information system development projects is proposed as a refined model that proposed by Yokota and Seki (2015a, b).

In Section 2, as a preparation for refining the project communication model of Yokota and Seki (2015a, b), some precondition for the proposed model is arranged through discussions of the basic and conceptual project communication model and the relationship between the project communication model and consensus-building in project organization. To obtain the refined model, the elements of project communication model of Yokota and Seki (2015a, b) are reconsidered and reconstructed. This renewed model is called the hybrid communication model.

In Section 3, the parameter set to determine the quality of project communication in the proposed model is also considered. In the discussion, the characteristics of communication in information system development projects are considered, and the discussions by Sperber and Grice, which is a great basis for communication, are introduced as basis in evaluating the quality of project communication. Accordingly, the metrics of quality evaluation for the mutual cognitive environment and the rule set in the proposed hybrid communication model are defined.

In future study, simulation experiments that employ multi-agent simulation technique should be performed to evaluate the validity of the proposed model for practical information development project risk evaluation. Yokota and Seki (2016) will present this simulation result.

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REFERENCES

Agarwal, R. and Umphress, D. (2010) A Flexible Model for Simulation of Software Development Process, *Proc. 48th Annual Southeast Regional Conference*, ACM, 1-4.

DeFleur, M. L. (1966) *Theories of Mass Communication*, David McKay Company.

Grice, H. P. (1961) The Causal Theory of Perception, *Proc. Aristotelian Society*, **35**, 121-153.

Grice, H. P. (1989) *Studies in the way of words*, Harvard University Press.

Khan, K., Qadri, S., Siddique, A. B., Ayoub, A. and Saeed, S. (2014) Evaluation of PMI's Risk Management Framework and Major Causes of Software Development Failure in Software Industry, *International Journal of Scientific & Technology Research*, **3**, 120-124.

Lewis, D. (1969) *Convention*, Harvard University Press.

Mitome, K., Seki, T., Nakano, B. and Takahara, Y. (2007) Decision Making Model of the Construction Project Organization: Consideration from the Rational Organization Model and the Garbage Can Model, *Journal of the Society of Project Management*, **9**, The Society of Project Management, 27-34. (in Japanese with English abstract)

Osgood, C. E. (1957) *The Measurement of Meaning*, Univ. of Illinois Press.

Schramm, W. (1954) How communication works, *The Process and Effects of Mass Communication*, 3-26.

Schiffer, S. (1972) *Meaning*, Clarendon Press.

Shannon, C. E. (1948) A Mathematical Theory of Communication, *The Bell System Technical Journal*, **27**, 379-423.

Shannon, C. E. and Weaver, W. (1949): *The Mathematical Theory of Communication*, University of Illinois Press.

Sperber, D. and Wilson, D. (1995) *Relevance: Communication and Cognition, 2nd Edition*, Wiley-Blackwell.

THE STANDISH GROUP (2013): *The Chaos Manifesto*, The Standish Group International.

Wickenberg, T. and Davidsson, P. (2003) On Multi Agent Based Simulation of Software Development Processes, *Multi-Agent-Based Simulation II*, Springer Berlin Heidelberg, 171-180.

Yokota, S. and Seki, T. (2015a) Communication Model of IS Development Project for Project Risk Analysis - Analysis of IS Development Project Performance using Multi Agent Simulation -, *Proc. 9th International Conference on Project Management (ProMAC) 2015*, 434-441.

Yokota, S. and Seki, T. (2015b) On Project Management Model for Multi Agent Simulation - Analysis of IS Development Project Performance using Multi Agent Simulation -, *Proc. the Asia Pacific Industrial Engineering & Management Systems (APIEMS) Conference 2015*, 1348-1355.

Yokota, S. and Seki, T. (2016) Evaluation of Modified Hybrid Communication Model - Project Risk Analysis of IS Development Project by Multi-agent Simulation -, (to be appear in *Proc. 10th International Conference on Project Management (ProMAC) 2016*).