NEGOTIATING APPROACH TO REQUIREMENT DEVELOPMENT IN ENGINEERING PROJECT

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ABSTRACT

The requirement development through client negotiation is a strategic task in projects. Under various constraints, such as cost, schedule and available resources, most project performance is defined in this task. It is, however, difficult to translate negotiation techniques into trade-off studies, because of its repetitive and cooperative disputation process. In this paper, the authors propose an systematic approach to strategically specify negotiation points that reduce such vague issues.

INTRODUCTION

The client's requirements are becoming more complicated with various applicable technologies. This may cause some disagreements between the client's expectations and design specifications in engineering projects. In the previous works[1], the authors focused on a fundamental structure of project scopes that derived from the user's requirements and proposed several risk management methodologies. In these methodologies, risk propagations are effectively reduced by controlling unexpected change orders with increasing flexibility of tasks against expected change orders. These methodologies are prepared for adequately articulated requirements that are easily translated to engineering specifications. In the actual situation, however, it is difficult to make the clear description of client's requirements and divide them into independent functional specifications. Some requirements can be firmly neglected or ignored and other requirements can be explicitly allocated to the known functions. In this requirement breakdown process, we create unconsciously a lot of interfaces among functions and strive to consistently maintain such interfaces in documents, such as specification sheets and drawings.

In the process engineering field, the authors dealt with the problem of requirements definition as a kind of design activity with tough negotiations between clients and contractors. In an engineering-oriented project, the contractor is playing important roles in defining good requirements, because of higher potential based on many experiences in the planning and execution of similar projects. The client usually prepares a kind of preliminary requirements which are characterized by involving ideal and unrealistic items or contents. The determination of the system's components and their relationships are usually made by engineering contractors based upon the incomplete client's requirements. Then the engineering result is to be negotiated between the client and the contractor on the basis of the differences caused in the context on the requirements definition.

In this paper, the authors focus on a negotiation process in an engineering project where client's expectations are translated to practical specifications under the limitation of engineering design technology, and propose a requirement development method for responding to the requirements under fixing the specifications.

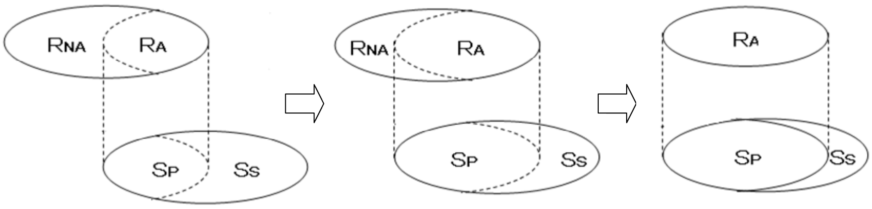

Fig. 1 Specification Development Process from Client's Expectations

R_A : Acceptable client's Requirements
R_{NA} : Not Acceptable client's Requirements
S_P : Primary Specifications based on contractor's available functions
S_S: Supporting Specifications related to contractor's available functions

PROBLEM STATEMENT

Background

As shown in Fig. 1, translating imperfect client's requirements into acceptable requirements, engineering techniques and design rules should be taken into account for developing the primary specifications with their supporting specifications. There are many methodologies have been reported in articles.[2][3] QFD (Quality Function Deployments) is one of the famous methodologies for defining the corresponding relationship between the clients' required quality (quality requirements) and the function to be considered in the design aspect. The design specifications are also provided in IEEE Std. 1220-1998[4]. In this standard, the corresponding relationship should be arranged with trade-off analyses under constraints imposed from the applicable engineering technologies. However, a method for introducing quality requirements in QFD strongly depends on engineers' expertise, and the specified trade-off analyses are also not completely disclosed in IEEE Std. 1220-1998.

Requirements are commonly classified as [5][6]

Constraints: a type of requirement and preordered design decision for the product or restriction on the project itself such as the budget or time allowed.

Functional requirements: an action the product must be capable or accomplishing and it is subtype of requirement.

Non functional requirements: a quality the product must have and it must be, for example, attractive, maintainable, and so on.

Technological requirements: an existence for serving the purpose of technology and only being considered when the technological environment is known.

In the specification development process shown in Fig. 1, there remain the questions; what degrees of the above mentioned elements can be translated into the primary specifications and what degrees of

Table 1 Generic Concern under Specification Development

	R_{NA}	R_A	S_P	S_S
Constraints	Has to be feasible in real situations	Has to be pushed to the contractor	Basically accepted as project constraints	Has to be profitable in making efforts
Functional Requirements	May be rejected, if they are non-realistic expectations	Has to be included, if they are realistic expectations	**Strategically negotiated based on the client constraints**	Technologically derived from contractor's design rules
Non-functional Requirements	May be rejected, if they are non-realistic expectations	Has to be included, if they are realistic expectations	**Strategically negotiated based on contractor's experience**	Technologically derived from contractor's design rules
Technological Requirements	To be adaptable in preferable selection	Has to be pushed to the contractor	Basically accepted based on the project policy	Technologically solved based on contractor's design rules

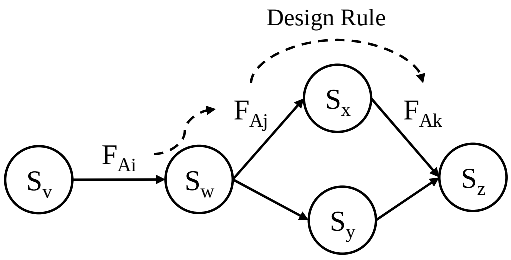

Fig. 2 Specifications, Applicable Functions and Design Rules

constraints imposed by the design rules and engineering techniques affect on the supporting specifications. Table 1 shows the generic concern under specification development. The present study is concerned with the functional and non-functional requirements as shown by the boldface in Table 1, since the constraints are taken always into consideration for projects and they seem to be the same, and the technological requirements are specific in every project so that it is not suitable to take here for generic discussions.

Problem Definitions

Yoshikawa et al. proposes a General Design Theory[4], where a design process is regarded as a mapping relation of design specifications to design solutions. In the above requirement development process, there are definitions as for requirements, specifications and design rules, as stated below.

Requirements (R): a set of functions (F_R), which are required for a client
Specifications (S): a set of functions (F_A), which are available for an engineering contractor
Design Rules: a set of dependent relation (δ_{ij}) between one available function (F_{Ai}) and another function (F_{Aj})

On the basis of these definitions, by applying the Yoshikawa's theory, the requirement development can be expressed by mapping a function space (S) to a requirement space (R) within the limitation of design rules. When the functions (F_A) are designated by arrows and the specifications (S) attained by the set of the functions (F_A) along the arrows are designated by nodes, the design rules can specify the routes in networks as exemplified by Fig. 2.

In this network, mapping the requirement space (R) to the function space (S) is accomplished by a series of negotiation between the client and the engineering contractor, two subjects are set as stated below.

Subject 1: how to determine negotiation points
Subject 2: how to make decision in negotiation

PROPOSED METHODOLOGY FOR THE REQUIREMENT DEVELOPMENT

Determination of negotiation points

In negotiation, related to requirement definition, between the engineering contractor and the client, the following two conditions are essential.

1) The requests of decision-making from the engineering contractor to the client should not be done step by steps.
2) The requests of decision-making from the engineering contractor to the client should be reduced as much as possible.

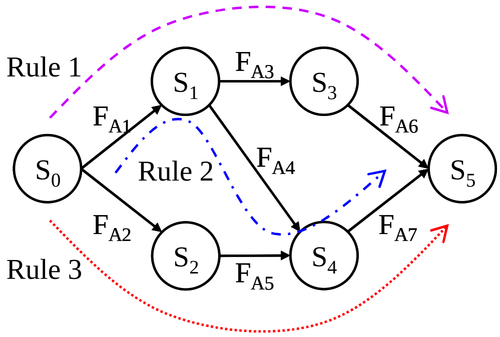

Fig. 3 Example of Specification Network with Design Rules

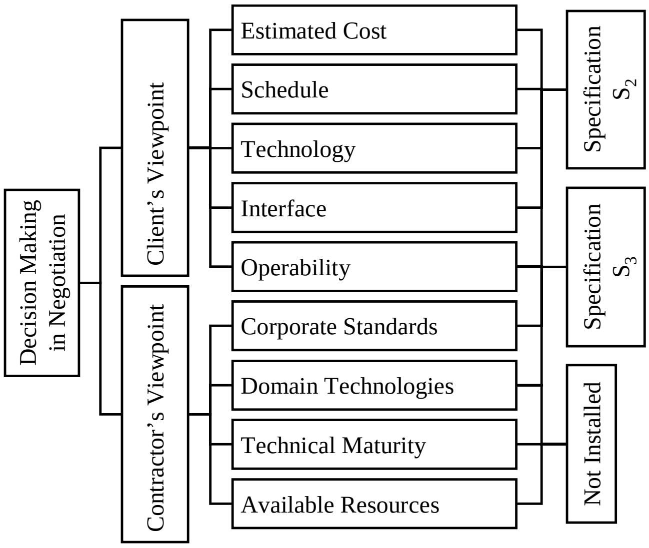

Fig. 4 Decision Making in Negotiation with AHP

That is to say, the selected design rules should reduce the number of routes as much as possible. Therefore, the subject 1 (how to determine negotiation points) corresponds to search a special node having the smallest number of routes, which pass through this node, among all routes formed between the start and goal in the network stated before.

In this illustrative example shown in Fig.3, for attaining the specification S5 from the NULL (S0) state, three alternative design rules can be applied as follows:

Rule 1: FA1→FA3→FA6
Rule 2: FA1→FA4→FA7
Rule 3: FA2→FA5→FA7

As shown in Fig.3, there are three routes passing through the start S0 node and goal S5 and two routes passing through the S1 node and S4 node, and one route passing through the S2 node and S3 node. Accordingly, it is clear that the negotiation point is S2 or S3. Then, negotiation, for which node is selected S2 or S3, is carried out so as to obtain a design rule for the specification S5, which is to be finally attained.

Decision-making in negotiation

In negotiation, the specifications should be evaluated from the viewpoint of client and that of engineering company. Referring to IEEE Std 1220-1998 (Sec.6.1 Requirements analysis), there are evaluation elements from the viewpoint of the client and the viewpoint of the engineering contractor, as stated in the following:

Evaluation elements from the viewpoint of client: Estimated Cost (funding, cost and management policy), Schedule, Technology (design policy and design characteristics), Interface with outside and existing equipment, Operability

Evaluation elements from the viewpoint of engineering contractor: Adaptability to standards of the company, Domain technologies, Technical maturity based on established life cycle process capabilities, available Resources (physical, financial, and human resource).

Among various kinds of decision-making support systems, AHP (Analytic Hierarchy Process)[8] is applied because of its suitability for a multi-criterion decision making that involves the comparison of decision elements which are difficult to quantify. In this way, decisions are made at every negotiation point defined in the same manner as stated in the previous section, before starting the negotiation between the engineering contractor and the client. In the AHP evaluation shown in Fig. 4, for the specification S5, which is necessary for attaining the client's requirement in the example shown in Fig. 3, negotiable specifications S2, S3 or "not installing as a specification" can be alternatively selected. When "not installing as a specification" is selected, the client's requirement is to be neglected for the specification S5.

CONCLUDING REMARKS

To an engineering company, the treatment for the client's requirements is a very important activity. In this paper, as a requirement development methodology, the authors propose the decision-making method for satisfying client's requirements by means of the design rules limitation. In order to reduce unnecessary conflict with the client, negotiation points are systematically specified and negotiation strategy is evaluated in the proposed methodology. After this internal decision-making in the contractor, a business negotiation with the client can be held in order to classify the client's expectation into the three groups, 1) Possible requirement without any condition (Independent Requirements), 2) Possible requirement on some condition (Dependent Requirements), and 3) Impossible requirements.

As a result, by utilizing the proposed methodology, the procedure where client's expectations are translated to practical requirements within the limitation of engineering design technology can be efficiently attained.

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