

Modelling of the Tendering Process

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Abstract—The model of electronic tendering process was developed. The suggested model allows splitting tendering process into several stages from preparing of tender documentation to selection of a winner, which helps to specify input and output data of each stage and optimize all stages separately, namely maximize the effectiveness of their results and minimize the time spent on their accomplishing.

Keywords—e-procurement, tendering, group decision making.

I. INTRODUCTION

A tender is one of the most effective and fair ways to enter into a sales contract. It often helps to solve a problem of choosing the best solution in conditions of limited resources. In this case the validity of final decision determines the direction of further development of the project. Almost all progressive countries have already made significant steps toward the transition to electronic tenders [1]-[4] and in some countries online systems for electronic tendering are supported and developed at the state level [5].

An indisputable advantage of a tender as a way to find the project executor is that it can be applied to an almost any contract, selling both goods and services and signed between two businesses (B2B) or a business and an individual customer (B2C) and even a business and a government (B2G). Though these types of tenders have their own specific features, a basic workflow of the process is common for all of them.

Usually the tendering process refers directly to the stage of working with the participants of a tender [6]-[8]. However, in practice this stage is preceded by significant organizational work which consists of the selection of experts and arranging of customer's requirements, including the transformation of verbal descriptions of requirements in the formal readable form.

If the company which organizes the tender solves these tasks on a regular basis, it probably already has a list of experts with verified skills and an efficient mechanism of the organization of tenders. However, for companies conducting the tender for the first time or working in a variety of areas requiring the involvement of experts of various specialties, the organizational part of the tendering process can be quite complicated.

The purpose of this paper is to expand a workflow of the tendering process, split it into stages and represent it as a mathematical model for further optimization.

II. STAGES OF THE TENDERING PROCESS AND THEIR KEY FEATURES

The suggested process extends a common used scheme of a tender adding to it some extra steps.

A tender stage list may vary depending on the subject area or the country. Nevertheless, any tendering process must include following stages: pre-qualification, invitation to participate in tender, submission, evaluation of proposals, selection of the winner, archiving. In this paper it is suggested to add to this list two more stages: organization of tender committee and preparing of tender documentation.

A. *Organization of tender committee*

A tender committee can be created on a temporary basis or on permanent basis if tenders are

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conducted regularly. This organization should include experts and representatives of the customer. The decision maker may also be a part of the tender committee but in the development of solutions his voice has no significant advantages over the others. In this case after finishing of evaluation stage he should take into account all recommendations provided by the committee and make a decision on who should be selected as the executor of the project.

B. Preparing of tender documentation

In tender documentation members of the tender committee should list all requirements to the object of the contract (products or services). This document will allow potential contractors to prepare more detailed information about their proposals.

Tender documentation usually contains a detailed description of all project requirements, contract terms and tender parameters, such as the time of tender ending, its format and evaluation system. Main requirements to tender documentation are a clear structure and a list of key parameters, based on which the participant will be able to make a proposal.

C. Selection of potential contractors

After customer's approval, the tender documentation is published and can be accessed by everyone. In addition the committee may send it to some pre-selected potential contractors personally inviting them to participate in the tender.

Pre-selection is optional but desirable stage for complex projects such as building and engineering design. This stage demands from participants to provide a set of supporting documents. Organizer performs audit, assessing reputation, financial position, capabilities and professional qualification of each participant. According to audit results, participants are divided into different groups according to their abilities or are arranged into rating.

Thus, if the company organizes several projects which are common by area but different by complexity, it can associate lists of potential participants to the complexity of each project. For more complex or critical projects more qualified participants are invited, and for simple ones – less qualified, but less expensive participants.

D. Proposal submission

After getting acquainted with the tender documentation all participants prepare their proposals and send them to the tender committee. Potential participants must prepare their proposals in accordance with the requirements specified in tender documentation. Each proposal can be processed either manually or automatically. For example, e-tendering system can automatically reject applications submitted after the specified tender ending time.

In practice, this step can be a weak point in the system, especially if the system is public and each participant can see the proposals of other participants. In this case, the later the participant comes with his proposal, the more chances he has to understate prices and terms, so that his application will be noticed before others. Even if system is not public, in case of manual processing of incoming applications an unfair participant may try to find an insider, who can provide him with the desired information about competitors. Obviously, there are two ways to avoid it: either proposals should be sent in "envelopes" and all "envelopes" should be opened after closing of the tender, or the system should be made invulnerable to the influence of the human factor by implementing of automatic proposal processing.

E. Evaluation and winner selection

After tender is closed the tender committee should perform an evaluation of proposals and make a final decision on the choice of executor the project. Evaluation can be performed in different ways, but they must be based on honesty. This means that the evaluation should be performed in the way when the decision maker is not able to implicitly or explicitly give preference to the desired party.

In general evaluation stage includes:

- preparation of data, including survey of experts, obtaining experts evaluations using ranking and the analytic hierarchy process, processing and formalization of survey results;
- calculation of experts competence during a survey using coefficient of confidence in expert opinion;
- aggregation of evaluations using the modified method of ranks summarizing which takes into account the competence of experts.

F. Archiving

After finishing of the tender all documents related to it should be archived. It is necessary for future analysis of tender results, when with a help of this archive it will be possible to evaluate the effectiveness and real qualifications of the winner in the long term. It also can be used in similar tenders allowing to omit the pre-selection stage and send invitations to participate in the new tender to verified companies.

The results of each stage have a significant impact on subsequent phases and, accordingly, on the final decision [9].

III. MATHEMATICAL MODEL OF THE TENDERING PROCESS

Tendering process is characterized by a certain set of data [10]. There are sets of data that define statement of the problem: M – a set of criteria for evaluation of participants, N – a set of alternatives, that are proposals from potential contractors, S – a set of experts invited to evaluate participants in the tender.

The results of the tender are represented by following sets of data: GW – a set of vectors of ratings obtained as a result of experts survey, v – a vector of coefficients of confidence in expert opinion, D – a vector, which includes the final rating of participants.

Thus, the tendering process P can be represented by the following tuple:

$$P = \langle M, N, S, GW, v, D \rangle \tag{1}$$

where

$$M = \{M_i \mid i = 1..m\} \tag{2}$$

$$N = \{N_i \mid i = 1..n\} \tag{3}$$

$$S = \{S_i \mid i = 1..s\} \tag{4}$$

$$GW = \{GW_i \mid i = 1..s\} \tag{5}$$

$$v = \{v_i \mid 0 \leq v_i \leq 1, i = 1..s\} \tag{6}$$

$$D = \{D_i \mid \sum_{i=1}^n D_i = 1, i = 1..n\} \tag{7}$$

where M – a set of criteria for the participants evaluation;

m – a number of criteria used in the tender;

N – a set of proposals from potential contractors;

n – a number of participants;

S – a set of experts invited to the tender committee;

s – a number of experts;

GW – a set of vectors of ratings obtained as a result of experts survey;

v – a vector of coefficients of confidence in expert opinion;

D – a vector, which is the final rating of participants.

On the preparatory phase all input data and parameters of the problem are formalized. At the initial stage of the tender during the organization of the tender committee, a set S of experts whose opinions will be taken into account when making a decision is determined. Then, the preparation of tender documentation is made. It includes selection of a set of project criteria M from a set of all possible criteria of evaluation. The process of pre-selection of potential contractors includes determining of a set N .

Proposals analysis based on obtaining evaluations by experts, as well as evaluating of competence of the experts themselves are the most important and difficult stages of the tendering process, and they require using of mathematical methods for their performing. The problem of a decision making P_{DS} itself can be represented as a set of data:

$$P_{DS} = \langle T, N, M, X, F, G, GW, v, D \rangle \quad (8)$$

where T – a statement of the problem (to select a better alternative, or to organize the entire set);

X – a set of methods for measuring preferences;

F – a mapping of valid alternatives to a variety of criteria evaluations;

G – a system of expert preferences;

D – a decisive rule that reflects a system of preferences.

In this problem the mapping F of sets N and M is uncertain.

A set X can be represented in both absolute and relative scales of measuring of experts preferences.

System of preferences G is formed by a group of experts.

The result of this stage is a set of ratings of alternatives GW , developed by experts, and a vector of coefficients of confidence in expert opinion v .

A vector D (rating of participants) is calculated based on results of the evaluation stage.

Thus, the main purpose of the tendering process is to provide a following mapping:

$$f: N \rightarrow D \quad (9)$$

where mapping rule is the procedure of rating determining based on experts evaluations.

IV. EXPERIMENTAL APPLICATION OF THE SUGGESTED MODEL

The developed model formed the basis of the new information system architecture. Each stage is represented by a separate module for better flexibility of entire system. Each module contains a set of methods performing data processing.

The efficiency of the information system was investigated. For experimental investigation information about tenders which took place in past was used. It was provided by building and engineering design companies.

As experimental data related to finished tenders, it was possible to compare real results of tenders with recommendations of the system and evaluate successfulness of real results in the long term. During experimental investigation some potentially weak solutions were discovered and unsuccessful tender results were predicted.

V. CONCLUSION

The developed model of the tendering process provides consistent partitioning of this process into several stages from setting the problem to making final decision. Decomposition of the complex process helps to get clearly defined sets of input and output data used on each stage

and to optimize each of them independently.

Using of this model as a basis of an information system allows creating a flexible, modular architecture consisting of independent components. Such architecture increases the efficiency of its use in a variety of subject areas.

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