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Developing a new method to model the causal relationships in stakeholder management at companies by using Fuzzy Cognitive Map Approach

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Abstract: The aim of this paper is to investigate the operation of a Stakeholder Relationship Management System (SRMS) as a method for business management and project support by fuzzy approach. The criteria defined in connection with the SRMS will be modelled by using the Fuzzy Cognitive Map (FCM) approach in order to define the causality and weights of interconnections between the factors and to support decision making in that way.

Keywords: Stakeholder Relationship Management System, Fuzzy Cognitive Map, Bacterial Evolutionary Algorithm, factor reduction model

1. Introduction

Every organization, project, program or even activity has its own stakeholders who are interested in the topic in different ways. Stakeholders could have on one hand different interest on the other hand different attitude regarding the investigated company. In that

way stakeholders can influence the success of the activity in diverse ways but in definite cases absolute decisively. The aim of the stakeholder management is to set up a positive and effective relationship with the interested parties and so it can contribute to the successful operation of an organization or to an effective completion of a project. Identifying the stakeholders and grouping of them by definite parameters is the baseline for all further measures [1].

2. Research assumption

Deeper knowledge about the stakeholders of a company and the better management of them contributes to the more effective operation. To get a brighter picture there is a need of deeper assessing the stakeholder structure of an organization. Companies are mainly using inquiry techniques or checklist-surveys to get a more accurate level of information about the stakeholders or even about the organizational issues regarding management processes in the organization.

The commonly used techniques are suitable to outline the stakeholder structure in a static way, so with the help of them the experts aren't able to get information about the system dynamics and the interconnections between the main drivers of the system.

The objective of the current research is to develop a methodology wherewith the dynamic modelling of a mapped stakeholder system would be achievable. Knowing the interconnections between the driver elements and the causality and weights of them can help in better understanding of a SRMS.

The authors of this paper are studying the applicability of the Fuzzy Cognitive Map methodology (FCM) for this modelling purpose.

3. Applied methodology

Stakeholder analysis investigate traditionally two different dimensions, namely the involvement of the stakeholder (from low to high) or the influence made by them (opposing or supporting).

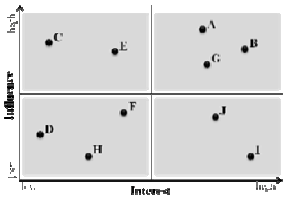

Figure 1. Classic approach of stakeholder analysis

The two-dimensional static approach of the interconnections between the interested parties gives sufficient information for setting up suitable management strategies but it hides also the nature of these connections, the casual correspondences of the system and its cross cutting connections. Researches regarding stakeholder management investigate mainly the ideal strategies set up on bases of the two dimensional approach, the concrete activities and applicable management techniques in connection with them.

Modelling of the casual relations between the stakeholders and characteristics is not in the focus of the current research.

The aim of the research presented in this paper is to model the interconnections between the main criteria of the SRMS and to make conclusions for the application of effective methods to manage the regarding issues. The FCM approach will be used as a method for the analysis. With help of the FCM method the casual relationships and the weight of these relations between the defined factors (in this case: the criteria's defined regarding the SRMS) could be investigated. FCM is an ideal tool for modelling multi-discipline systems, especially in that case when they incorporate 'soft' parameter as human factors, environmental characteristics or social relations [2].

As a research design the authors will choose the following. As a first step the main driver elements of a SRMS will be defined. This driver elements (in the FCM so called concepts) will compose the baseline for the model and they are the nodes where the interconnections, and their causality will be modelled by FCM. Appropriate defining of these nodes are elementary for the proper working of the method chosen. Results of scientific examinations and notions of practitioner business managers will be used for this step.

After defining the nodes the possible causality and the weights of the connections will be measured by interviewing company and scientific experts. In the course of the interviews the researchers will search for answers for the following issues (where X; Y and Z defines one of the above mentioned main categories):

- the significance of the nodes in the SRMS;
- effects which can change the present (balanced) situation and their main driving factors;
- the size and way of the effect (small/medium/large; positive/negative) which concept X have on concept Y;
- processes and changes that are affecting X;
- the direction and nature of changes by X when Y becomes smaller/bigger; the effect of this changes on Z;
- the correspondence between the changes of X and Y;
- the causal relationship between the categories and the nature of the connection;

The results of the investigation will be used as an input data for the FCM-model.

Beside that the research group will use input variables from a during the research designing step finished analysis based on questionnaire. The input variables of the model in that situation are the 48 indicators of the SRMS, which were defined by using academic literature data regarding existing attitude of companies in connection with stakeholder management. The relative weights of these 48 indicators was investigated with the help of a statistic sample of nearly 600 entries. The sample incorporates the five biggest transport companies of Lithuania. The relative weights data derived from the incoming answers will be used for setting up the FCM model. We are planning to use the Bacterial Evolutionary Algorithm (BEA) approach for the FCM.

To get an appropriate database for the model development it's necessary to obtain information from the questionnaire that are suitable for the analysis of causality effect between each nodes. One possible solution to get such an information is an stratified question setting. In that case the same questions are asked in different moments to get information about the changes in the weights of the nodes. From the changes in values given by the respondents conclusions can be concluded for the causality-effect.

As a first step all of the mentioned 48 indicator of the questionnaire will be used for the model setting and to understand the general logic of the system. After that a significant data reduction is planned to reach a more manageable model. The data reduction will be achieved in two steps. First and foremost the grouping of the questions will be realized, after that a newly developed concept / factor reduction model will be used for that purpose. In this way the most substantial factors or factor-groups can be highlighted.

4. Expected results

The results of the model can be used for understanding the cross-cutting effects of the 48 criteria and further to support decision-making. The FCM-model of the SRMS will give detailed information about the interconnection of the identified drivers and the causality effect between them. Another result of the model will be the identification of the stationary position of the SRMS model and the most typical interactions in that position.

5. A short overview of FCM

FCM seems to be an applicable technique to model the behaviour of SRMS, because it was developed to analyse and model complex systems [A]. FCM is a directed, signed fuzzy graph structure [B], and can be considered as a combination of fuzzy logic and neural networks.

This graph contains two main elements: the so-called concepts (denoted by C_i), which are represented by vertex, and the edges, which represent the weight and direction of connections between concepts (denoted by w_{ij}). The concepts represent the main driving factors or the main components of the modelled system (see Fig. X). The data of the edges are collected into a squared matrix, the so-called connection matrix. This matrix contains only zeroes in it's main diagonal by definition, but other elements are in the [-1, 1] interval, while the values of the concepts must be in [0, 1].

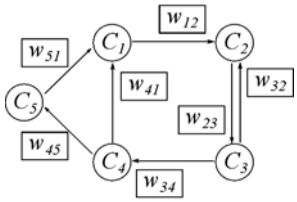

Figure 2. FCM graph of a modelled system

If the initial state of the concepts and the elements of the connection matrix are known, FCM is able to simulate the dynamic behaviour of the system. These prerequisites are often insured by experts of the investigated field. Care must be taken to provide only objective data, because the experts are often influenced by their already existing subjective convictions [C].

The consecutive states of the system (or time steps) can be calculated using the transition function with a simple loop, until an equilibrium state is achieved or other termination condition is fulfilled.

$$V\_(k+1)=f(N\cdot V\_k) \tag{1}$$

Here, $\mathbf{V_k}$ is the kth state of the concepts, $\mathbf{N}$ is the connection matrix and $\mathbf{f}$ is the transition function. The definition of it is the following:

$$f(x) = \frac{1}{e^{-\lambda x}} \tag{2}$$

In Eq. Y λ defines the steepness of the transition function. The value of it is always in [0, 1].

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