

EVALUATING RISKS IN SOFTWARE NEGOTIATIONS THROUGH FUZZY COGNITIVE MAPS

Sergio Assis Rodrigues¹, Efi Papatheocharous², Andreas S. Andreou² and Jano Moreira de Souza¹

¹COPPE/UFRJ – Computer Science Department, Federal University of Rio de Janeiro, Brazil

²University of Cyprus, Dept. of Computer Science, 75 Kallipoleos str., CY1678 Nicosia, Cyprus

Keywords: Risk Management, Fuzzy Cognitive Map, Negotiation, Cost Estimation, Decision Making Process.

Abstract: Risks are inevitably and permanently present in software negotiations and they can directly influence the success or failure of negotiations. Risks should be avoided when they represent a threat and encouraged when they denote an opportunity. This work examines the influence of some negotiation elements in the area of risk and cost estimation, which are both factors that directly influence software development negotiation. In this work, risk quantification is proposed to translate its impact to measurable values that may be taken into consideration during negotiations. The model proposed involves an assessment tool based on basic negotiation elements – namely relationship, interests, cost and time – quantifying the influences among each other, and makes use of Fuzzy Cognitive Maps (FCMs) for developing the associations around basic risk elements on one hand and attaining an innovative risk quantification model for improved software negotiations on the other. Indicative scenarios are presented to demonstrate the efficacy of the proposed approach.

1 INTRODUCTION

This work approximates the issue of constructing optimal goal-oriented risk and cost management strategies to avoid risks during software negotiations. In this phase, both the schedule and cost approximations are highly affected by several critical issues concerning the increasing rivalry of competitors, the demand for shorter project life cycles and cost reductions; however, they have no compromise on the quality constraints. Appropriate regulation of these constraints is decisive in order to either gain or lose a contract, outrun schedules, budget and misallocate project resources. Especially in the initiation phase of a project, there are many uncertainties and risks to be considered.

Negotiations and conflict resolution can be responsible for influencing relationship maintenance and leading the institution towards success or failure, depending on the staff performance. In general, the goal is to reach the planned agreements; however, as in all decision-making processes, negotiation is directly related to risk assessment. Therefore, the correct management of risks allows one to lead a negotiation in a structured and proactive way, introducing strategies that may prevent,

control and mitigate the risks that can lead to negotiation failure.

Some particular elements are usually more discussed in negotiations, such as scope, time, costs, required changes, relationship, interests, administrative issues, contract clauses and resources (PMBOK, 2004). The perception of risk in some negotiations is more significant, but, as (Bartlett, 2004) states, risk is an element found in all negotiations, no matter their nature. Nevertheless, the challenge is to know how to quantify risks in order to prioritize them and, consequently, avoid future problems.

This article attempts to show an approach to quantify risks anchored in key negotiation elements. An FCM model is utilized taking into consideration these negotiation elements to improve the negotiation process.

2 TECHNICAL BACKGROUND

In a decision-making environment, a systematic method to manage risk may provide enough information to negotiators and additionally, utilizing negotiation elements to assist risk management may

be an innovative aspect for any organization entrepreneur. Moreover if the negotiator is aware of the existing risks involved and realize that may be considered either as threats or opportunities may result in optimized agreements (Rodrigues, 2008). On the other hand, there are several weaknesses in the approach proposed which denotes that risk is a simple multiplication between probability and impact. In order to improve the approach, this work additionally examines the use of Fuzzy Cognitive Maps (FCM) (Papatheocharous, 2008) to illustrate a negotiation result. The idea is to compare the use of the basic simple formula of probability and impact, with the results obtained through FCM simulations and, consequently, propose an innovative improved risk quantification model.

A Fuzzy Cognitive Map (FCM) is a diagram consisting of nodes and arrows; the nodes represent various qualitative concepts, while the arrows denote the links between the concepts. Each concept is characterized by a numeric activation value denoting a qualitative measure of the concepts' presence in the conceptual domain. Thus, a high numerical value indicates that the concept is strongly present while a negative or zero value reveals that the concept is not currently active or relevant to the conceptual domain. When a strong positive correlation exists between the current state of a concept and that of another concept in a preceding time-period, we say that the former positively influences the latter. This relationship is indicated by a positively weighted arrow directed from the causing to the influenced concept. By contrast, when a strong negative correlation exists, it reveals the existence of a negative causal relationship indicated by an arrow charged with a negative weight. Two conceptual nodes without a direct link are, obviously, independent.

The updating function of a CNFCM is the following:

$$A_i^{t+1} = f(S_i^t A_i^t) - d_i A_i^t \tag{1}$$

$$S_i^t = \sum_{\substack{j=1 \\ j \neq i}}^n A_j^t w_{ij} \tag{2}$$

where A_i is the activation level of concept C_i at some time $(t+1)$ or (t) , equation (2) is the sum of the weighted influences that concept C_i receives at time step t from all other concepts, d_i is a decay factor (Tsadiras, 1998), and (3) is a modified version of the function used for the aggregation of certainty factors (Kosko, 1994).

$$f_m(A_i^t, S_i^t) = \begin{cases} A_i^t + S_i^t(1 - A_i^t) = A_i^t + S_i^t - S_i^t A_i^t, & \text{if } A_i^t \geq 0, S_i^t \geq 0 \\ A_i^t + S_i^t(1 + A_i^t) = A_i^t + S_i^t - S_i^t A_i^t, & \text{if } A_i^t < 0, S_i^t < 0, |A_i^t|, |S_i^t| \leq 1 \\ A_i^t + S_i^t / (1 - \min(|A_i^t|, |S_i^t|)), & \text{otherwise} \end{cases} \tag{3}$$

3 RISK QUANTIFICATION

The importance of risk quantification is to provide, numerically, the impact offered by a risk to a negotiation, in the case that it occurs. Generally, "risk value" is calculated through the Expected Value analysis, obtained by the multiplication of occurrence risk impact and probability (PMBOK, 2004). This work uses a mathematical method with associated weights to the key negotiation's elements: namely cost, time, interests and relationship.

Time and Cost are measures that can be expressed in numbers (e.g., 6 months, US\$500, etc.) and are primarily the key concepts affecting the negotiation process and will have a profound impact on the later stages of development. The proposed tool allows negotiators to indicate the weights and values of the best and worst cases for each negotiation element respectively. These values will then be used to normalize the risk impact for the quantification step. Thereafter, the four negotiation elements will have different weights and the value of the adjusted impact will be between the range of 0 and 100. At the end, the normalized risk impact is calculated by:

$$Impact = \sum \frac{w_i * v_i}{|b_i - p_i|} \tag{4}$$

The above formula provides the expected value of each risk, negative or positive. Index i represents the element that varies from 1 to 4. Variables w_i , b_i and p_i represent the weight, the best case and the worst case respectively for each element. Variable v_i is called the Affected Value, whose significance is asserted by negotiators.

Afterwards, the Risk Expected Value is calculated through the multiplication between risk probability, acquired from historical experiences, and impact, obtained from equation (4). Finally, considering all identified risks, a negotiation's weighted average is estimated. This estimated value will be used as the initial activation level of the corresponding concept in the FCM.

4 MODELLING THE EXPERIMENT

Through the negotiation experiments executed we were able to create associations to guide the construction of an FCM model to assess (predict) the outcome of the negotiation process in qualitative terms. Figure 1 shows the corresponding model formed reflecting the negotiation scenery:

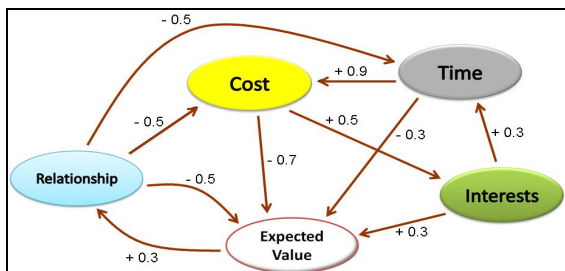


Figure 1: FCM modelling the outcome of the negotiation.

Cost (C) directly positively influences the client’s and developer’s interest. Increased anticipated costs draw more attention on behalf of the senior management whereas high costs hinder the successful conclusion of a negotiation.

Time (T) represents the development time needed to complete and deliver a software product. Time influences positively Cost and negatively the expected outcome of a negotiation.

Interests (I) represent the commitment level and the interest of management (both in client and developer organizations). Generally, several interests imply overhead in time during development as more time is consumed in communication.

Relationship (R) reflects the level of communication, understanding and possibly trust between client and developer. In general, this element influences costs and time negatively and positively the negotiation output (good communication contributes to faster development, with lower costs and improves successful deals).

Expected Value (EV) represents the outcome of the negotiation. High activation means that negotiation is successfully concluded and low exactly the opposite. Hence it may be considered a risk indicator of the course of negotiation.

In this case study, Copp, an Information Technology research and software development institution employing around 150 professionals (managers, developers and research staff) was the Service Supplier. The Client of this negotiation was BraxPetrol institution, a global oil exploration and production company, operating in Brazil.

Table 1: Influences between concepts in the FCM negotiation model (column is the source).

	C	T	I	R	EV
C		0.9	0	-0.5	0
T	0		0.3	-0.5	0
I	0.5	0		0	0
R	0	0	0		0.3
EV	-0.7	-0.3	0.3	0.5	

The relationships of Figure 1 relate to a numerical state indicating the influence exercised by the source node to the destination node. These weights are listed in Table 1. The underlying weights and the values of the activation levels of the participating concepts are illustrated on a five-scale scheme equally spread in the range [-1, 1].

5 EXPERIMENTAL RESULTS

This section presents three negotiation scenarios which were used to investigate the efficacy of the model. The first and third represent the two extreme cases of the worst and best circumstances in terms of parameter values that hinder or promote successful conclusion of the negotiation. The second case lies somewhere in between:

Negotiation 1: The worst agreement setting

- C → Very Bad : Interpreted as Very High (0.8)
- T → Very Bad : Interpreted as Very High (0.8)
- I → Regular : Interpreted as Low to Medium (0.2)
- R → Bad : Interpreted as Low (-0.5)
- EV → Bad : Interpreted as Low (-0.5)

Negotiation 2: A medium agreement setting

- C → Good : Interpreted as Low (0.5)
- T → Bad : Interpreted as High (-0.5)
- I → Good : Interpreted as High (0.5)
- R → Good : Interpreted as High (0.5)
- EV → Good : Interpreted as High (0.5)

Negotiation 3: The best agreement setting

- C → Excellent : Interpreted as Very Low (-0.9)
- T Excellent : Interpreted as Very Low (-0.9)
- I → Good : Interpreted as High (0.5)
- R → Good : Interpreted as High (0.5)
- EV → Excellent : Interpreted as Very High (0.9)

Each negotiation case study involved executing the map for 250 iterations when it reaches in a final immutable situation characterized by equilibrium. In each respective iteration the new activation level value for each concept was calculated using equations (1) to (3) as explained earlier. The final values of the activation levels are listed in Table 2.

Table 2: Final activation levels of the concepts in the FCM negotiation model.

	C	T	I	R	EV
Negot.1	1.0	0.93	-0.83	0.91	-0.85
Negot.2	1.0	0.93	-0.83	0.91	-0.85
Negot.3	-1.0	-1.0	0.84	-0.91	0.86

Analyzing the results of Table 2 we observe that the model behaves as it should have. More specifically, in the worst and best scenario cases the value of the negotiation concept stabilizes at -0.85 and 0.86 which suggests that the final outcome will eventually be negative and positive respectively. The rest of the concepts behave also as expected. In the worst case negotiation both cost and time are driven to even more negative values than originally started, while it is interesting to note that Interest becomes negative, which indicates that senior management stops participating in "lost" cases and devotes their time to other more beneficiary projects. Additionally, Relationship becomes more positive signifying that trust and good communication may not be hampered in cases where the negotiation is ended without consensus due to infeasible development that results from unsatisfactory time and cost projections.

The exactly opposite picture is observed for the best case where a mirroring to the above set of values again justifies the correctness of the model in capturing properly the dynamics behind such promising negotiation scenery. Finally, we should comment a bit on the results of the medium state, where we can discern that the outcome of the negotiation is closer to the negative value. This is also quite natural as it is clear from the behaviour of the model that the two leading factors are cost and time and once this suggest a negative development expectation then negotiations are doomed to fail.

6 CONCLUSIONS

Negotiations are generally subject to many types of risks. As previously discussed, a risk element can influence negatively or positively the software development and should be identified during negotiation preparation because of the necessity of having a real view of the context in which the negotiation decision will take place. This work aims at addressing a strategy to facilitate risk identification and quantification, inferring to the suggested expected value and based on critical negotiation elements or concepts.

The work also examines the importance of evaluating the risk assessment method through the use of Fuzzy Cognitive Maps. The model proposed obtains the appropriate associations among the negotiation elements through real negotiation experiments and evaluates the result. Three hypothetical scenarios were executed taking into consideration the key concepts of: contract's cost development, development time, counterparts' interests, counterparts' relationship and negotiation's expected value. The results showed that the method is promising as the model reacts with the way it was expected to.

Finally, we might suggest that the method of risk quantification using proportionally weights and impacts to evaluate risks in cost, time, relationship and negotiation's interests is capable to facilitate the identification of preponderant threats and opportunities and leads to better negotiations.

Conclusively, for future work the innovative tool proposed may be further examined to involve other supplementary elements to the software, which may also be included in the assessment model of Fuzzy Cognitive Maps (FCM), and make inferences in different negotiation areas to examine the methods generalization to other backgrounds.

REFERENCES

- Bartlett, 2004, Bartlett, J. "Project Risk Analysis and Management Guide", Second Edition ed., UK: Apm Publishing Limited, 2004.
- Kosko, 1994, Kosko, B., "Fuzzy Thinking. The New Science of Fuzzy Logic", London: Harper Collins.
- Papatheocharous, 2008, Papatheocharous, E., Rossides, G. and Andreou, A. S. "Qualitative Software Cost Estimation Using Fuzzy Cognitive Maps", AISEW - Artificial Intelligence Techniques in Software Engineering Workshop at 18th European Conference on Artificial Intelligence, Patras, Greece, 2008.
- PMBOK, 2004, PMBOK. "Project Management Body of Knowledge", 2004 Edition. Project Management Institute, <http://www.pmi.org>, 2004.
- Rodrigues, 2008, Rodrigues, S. A.; Vaz, M. A.; Souza, J. M. "A Software to Manage Risks in Project's Negotiations". In: WORLDCOMP'08 The 2008 World Congress in Computer Science, Computer Engineering, and Applied Computing, Las Vegas.
- Tsadiras, 1998, Tsadiras, A.K. and Margaritis, K.G. "The MYCIN Certainly Factor Handling Function as Uninorm Operator and its Use as Threshold Function in Artificial Neurons", Fuzzy Set and Systems, Vol. 93, 263-274, 1998.