Project Negotiation Modeling with Bayesian Network

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Abstract

One of characteristics of project negotiations is that they are growing complex very fast, because there are so many things to negotiate. In our research, negotiators are to deal with two parameters at a time (one parameter is money) on a separate Visual Models. To negotiate three or more parameters simultaneously considered to be over-confusing for a human being. The output of the Visual Models in the form of a mathematical expressions will be input into the Nodes Graph of Bayesian Network decision making software, where negotiation variables are broken into pairs of nodes, forming a simple model of variables that are individually connected to the skeletal chain of money nodes. Parameter's probability status will be automatically updated with new uncertainties through the mathematical relations network. In this way, all the parameters of negotiation will be indirectly interrelated. Depending on the cases of the negotiation, specific layout of negotiation conditions should be developed on the Visual Model and Nodes Graph. Negotiators will get an intuitive/visual grasp of the negotiation's big picture, quantitatively understand any risks involved.

After all, a human is the one to make final decisions.

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1. Introduction

Business negotiation in Project Management is a quite complex work, while at the same time a determinant moment in any business activity. The complexity and potentiality of negotiation to some extent are underestimated among project engineers of today. There are many different aspects to be taken into account such as; goals, stages, conditions, players, uncertainties, multi variables and so on.

In the recent years some considerable work has been done to use a BN (Bayesian Network) in negotiations, but emphasis is more on the automated negotiations [1] [3], or the study is very generic or over theoretical aimed at trying new possibilities of the Bayesian Network approaches [4] [5]. Yet other work is mainly on psychological and organizational aspects of negotiation process and meant to develop strategies and tactics to get advantage over the opponent. Interestingly enough is that the complexity of the information flow and interpretation capability by human are often ignored. No dedicated work, as far as we can judge, is done to specifically understand and categorize the pre-contract business negotiations on a complex projects where the human is ultimate decision maker and no pure-computational approach is realistic.

In this paper the authors suggest that being able to put all the relevant elements of a negotiation conveniently on a graphical visual model and have access to probabilistic analysis with this model, will contribute to understanding of relations between elements of negotiation.

We also assume that different conditions of negotiation with different balances are in principle the same but with varying importance of some elements over others. It will be easier to model situations if they are divided into categories based on importance of some of its elements.
2. Visual Model

The Figure 1 is the basic configuration that we are proposing for the Visual Model. Different cases for negotiation of two parameters in this paper will be derived from this graph.

![Graph](image)

**Figure 1, Basic Configuration**

The relation of money and time, taken as typical example of two negotiated variables, is as in the Figure 1. The monetary value of a project is continuously decreasing along the time axis. For simplicity, the curves we analyze are linear. The “minimum line” on the graph is the minimum money the engineering side will accept to finish the project at a given time. The maximum line is the maximum that client is willing to pay at a given time. The deadline is restriction usually imposed by the client in the form of fixed point in time. Overlapping area is where negotiation ranges are possible. Negotiation range is a vertical distance from point on a maximum line down to minimum line. If curves are not linear then there may be more than one overlapping areas. After taking into consideration all the restrictions the wider the range the better the business becomes for any of the sides.

Assuming that it is possible to meaningfully put all considerations of negotiation on the Visual
Model, we propose that sides use one common format for creating models for their own positions and models for estimation of opponent's positions on negotiation. Then at actual negotiation session they can combine their curves in one chart. Software used here will run calculations and highlight some potential areas to negotiate. The negotiators will see how the negotiation looks visually and will know what they don't like about it. During negotiation sessions they will interactively and counteractively adjust the graph.

3. Visualization of Negotiation

Before proceeding further, we are going to look at some selected cases from possible categories of situations in the business negotiations with the Visual Modeling.

3.1 No Trust Case

This is an extreme case when parties do not trust each other, as in cases when sides are doing business with each other for the first time and one or both sides are not planning to do business in the future with the same partner. See Figure 2.
The view is from client's perspective. Different from Basic Configuration in the Figure 1, we have introduced probability distribution curves and negotiation ranges sharing curve here. So the solid minimum and maximum lines are the lines that are openly disclosed by both sides of negotiation. The probability distribution curves in red, at the mean value point, show client's real estimate of his money-time relation that he hasn't disclosed to the opponent. It is probabilistically distributed because of natural uncertainty. The farther is the time to the future the more is the divergence (more defensive) of the claimed curve and the realistic estimates of the client. One reason is the mere uncertainty of the future, and another one is a desire to force engineering side to finish the job faster. The blue probability distribution curves and their positions reflect what the client thinks, is the real stance of the engineering side. From this Visual Model it can be understood quantitatively how important it is in this cases, where little trust is, to make bold claims in ones own favor. We decided that the negotiation range should be shared here at 50-50 portions, because the agents have no mutual trust, and their ability to compromise, and as a result have more optimal negotiation to some degree are impaired. The arrangements of the units of the Visual Model are not strictly defined, what we wanted to show here is how different aspects can be translated into the modeling language.
3.2 Partial Trust Case

In the Figure 3, again we look from the client's perspective.

![Graph showing partial trust case]

Figure 3, Partial Trust Case

Parties partially trust each other. Client’s claims are less distant from real estimates, and he sees the engineering side in less hostile light. Example for this could be, when the parties have some history of business relation and still have intentions to continue in the future. The negotiation range to be shared is not straightforwardly 50-50, this reflects degree of mutual trust and emphasizes clients need to meet the deadline and so he rewards engineering side more if he finalizes the project earlier. The software itself will come up with default negotiation range sharing curve as a result of inbuilt formulas, which can be adjusted manually, section by section, by the negotiators.
3.3 Total Trust Case

Figure 4 illustrates the situation when the information is not hidden and the parties fully trust each other, like in case of negotiation between segments of the same corporation.

![Figure 4, Total Trust Case](image)

The only uncertainty is born from natural causes. The negotiation range is most bended in this case to reflect the wish of the engineering side to be rewarded better for the earlier completion of the project and on the other hand to reflect the strictness with which client wants to stress the importance of the deadline.

4. Mathematical Relation

The negotiation balance of two parameters on the Visual Model will be transformed by software into sophisticated mathematical relation $S = R(t)$, where all visual units of the Visual Model will be transformed into algebraic meaning. That is; with a given amount of money invested into the project we will have some probabilistic distribution of time at which it will be completed, or vise versa, with given desired time for the project to be completed there will be some probabilistic distribution of money required/ agreed. This relation will be used as input in the BN Nodes Graph of
negotiation variables. Arrangement of variables nodes is explained in the next section.

5. Nodes Graph

On the Bayesian Nodes Graph, the parameters arranged as in the Figure 5, BN Nodes Graph. The order of the blue nodes could change depending on case.

Starting assumption is that there is a fixed amount of money, "capital", which client dedicates to the project. This, of course can be subject to uncertainty. Negotiation starts by agreeing on the first variable versus money required to fulfill requirements associated with it.

![Figure 5, Mathematical Translation of Visualized Model](image)

So as the variable (time in this case) is negotiated against money on the Visual Model, we get the mathematical relation from that model as one factor determining the amount and probability relation of "time" and "money2" nodes on the BN Nodes Graph. "money2" is amount that is left after money deducted for "time". Another factor is "capital"'s amount and probability distribution of this amount. In the same manner starting with "money2" we determine "n2" and "money3", and so on till the "remaining" amount, which will be left at the end, if ever left. As there is a clear chain of cause-effects from up towards down, there should be indirect but strong relation of all the variables through money factor.
6. Illustration Example

In the Figure 6, we have input some data into the BN model nodes and simulated some relation between elements. The relationship is simple.

"money2" = "capital" – "time"

Figure 6, Illustration with Probabilities.

All the nodes in the Nodes Graph are assigned some units with values from “0” to “10”. In the full version the values of the individual nodes should be expressed in their original units (time is in months, for example) and ranges. The conversion of units will be performed by the software using mathematical expressions.

The “capital” node is set to be 10 units with some uncertainty. Farther, “time” is 5 units at mean value, “n2” is 2 units at mean value, “n3” is 2 units at mean value, and the “others” node is 1 unit at mean value. All with appropriate probability distributions. Obviously, here we have a limit on a money so we must balance between the blue nodes competing for the same money resources. This is
a situation we usually encounter in real life negotiations. In extreme case when the "capital" has no upper limit and/or there is no minimum limit on the "remaining" where it can go even to minus, the "money" nodes are only affected by upper blue parent nodes. These blue nodes are independent from each other. We can freely assign adequate money values to meet their requirements, and only afterwards calculate how much money we need in total for the project.

To start with the BN Nodes Graph will require some initial exact or probable values for each node. This values must be carefully considered before assigning, to reflect initial knowledge state, the initial objectives or even from whose point of view is it modelled.

As the final result we have nodes arrangement which is simple for human to understand, and for computer to do the background calculations.

Figure 7, Illustration with Some Fixed Nodes
In the Figure 7 some nodes are fixed with given values and the rest stay as in Figure 6.

The "capital" node is fixed to be 10 units, the "time" node fixed to 5 units, the "remaining" is fixed to 1 unit, which is, let's say, a money left for contingency.

As can be observed, the "money2" node is not constant value as it should be if the value of the "remaining" node was not fixed, because the both parent nodes are constant values. In this same way all the nodes between the two parent nodes and the "remaining" node are inter-affected from up and down nodes.

7. Discussion

Modeling described in this paper will provide following:

Negotiators of both sides before any negotiation will have some list of requirements and their values to fulfil. Then together, after they are familiar with each others list of requirements they should agree on the order of the nodes on the BN Nodes Graph. Once this is done the next step will be to start to negotiate parameters in pairs beginning from the most important, that is form the top ones on the BN Nodes Graph, to less important ones.

Each side will have to prepare each time for negotiation of the two parameters, let's say "moneyx" and "nx". They will need to define their own real relation curve of "moneyx" vs. "nx" on the Visual Graph. At the same time they should be estimating the opponents real "moneyx" vs. "nx" relation, to be ready to confront it. Depending on both relations, they will need to come up with the relation that they are going to disclose in the actual negotiation session.

So during the negotiation session they will put their curves on one common platform of the Visual Model. Based on what they see on the screen with some help from computer they will know what to negotiate. As a result of this negotiation the maximum and minimum lines, some restrictions with their importance weights, range sharing curves and final uncertainties will be shaped. All these
visual elements will be translated to combined mathematical relation of “moneyx = R(nx)”. This relation will be used in BN Nodes Graph to tie relevant nodes. This process will continue until all the relevant nodes are tied on the BN Nodes Graph. This will be the end of first stage.

Now there will be a picture of all the parameters interrelated quantitatively. Probably, many things will not be satisfactory to one or both sides. Next negotiation sessions will be about smoothing these corners. Negotiations will be around initial value inputs into the BN Nodes Graph or around the Visual Model curves of some pairs of “moneyx” and “nx”. This process does not have a definite end and can continue even during the execution stage of the project.
8. Conclusion and future work

In the future we will be trying to better categorize different situations of negotiation. Category criteria may include: Which factor of the negotiation is a dominating in importance? What is the level of the trust between opponents? What are the external factors affecting the negotiation process? What stage of the negotiation is it in? And so on.

The Visual Model is very basic at this moment and the dynamics of the model units reflecting real life parameters are not well studied yet. It possible, that some elements will be added to or subtracted from the Visual Model.

On the BN Nodes Graph, all the parameters except the money are represented by blue nodes and are all connected to money nodes only. In some cases it could be more effective to have some direct links on the Nodes Graph between some blue nodes depending on unique negotiation situations. So by analyzing specific negotiation conditions some more customized models can be developed.

In this paper we just slightly mentioned about different types of uncertainty. In the context of negotiation there are two different uncertainty sources. One is created by negotiators while hiding or giving incorrect information, another one is natural uncertainty which is due to impossibility or infeasibility of predicting exact outcomes. So in many situations of negotiation these two should be handled differently, thus this needs to be properly reflected in the model.

Couple of times in this paper we have mentioned about software that will assist us in modeling and computations. Although to develop such software, it is out of scope of our research, nevertheless we should think about mechanics of software development when we work on the model. We have to consider for example, will the Visual Model platform allow us to drag elements of the model by toughing the screen, or when we make some changes to on of Visual Model will these changes affect other Visual Models connected to the same BN Nodes Graph, and so on.

We sincerely believe that if some widely accepted modeling language and standardization will be
possible in the future, be it the kind that we are proposing or another kind, this will make negotiations more approachable than they are today. In addition based on these standards, farther strategy developments will be easier. Communication of the knowledge of particular negotiations situations even among people who are not involved in the process will get easier as well.

It is believed that human beings have an innate capacity for cognitive modeling, and its expression through sketching, drawing, construction, acting out and so on, is fundamental to human thought.

References