Financial Effectiveness of Negotiation Support Systems

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ABSTRACT
Implementing negotiation support systems requires the commitment of significant amounts of resources within the host organization. This paper looks at the effectiveness of investments in these systems, looking at some standard indicators for economic efficiency and the impact of these systems on an organization's overall activities. This article is part of a research project spanning over a period of 3 years, aimed at developing a successful model for computer assisted negotiations.

KEYWORDS: *multi-agent negotiation, financial effectiveness, negotiation support systems, NSS, economic efficiency*

JEL CLASSIFICATION: *O14*

INTRODUCTION

Prior research conducted by Abrahams and Zeleznikow (2010) in the field of negotiation support systems (from here on referred to also as NSS or simply "systems") indicated significant benefits could be drawn from the implementation and use of systems based on adaptive modeling of negotiation processes. Aspects related to adaptive modeling had also been discussed by Lau (2009), Chen et al. (2008), Bo & Li (2011) and most recently Rosenfeld & Kraus (2012). The model versions which form the basis of discussion for this paper rely on unpublished results which are part of the global research project of this paper's coordinating author due for presentation and publication in 2012. In order to better understand the scale of the complete research project and the placement of the versions discussed in this paper a partial Gantt chart of the project is provided in the following pages.

A core component of the NSS is the procedure by which the system learns the behaviour of human agents, taking into account the subjective nature of the negotiation process as a whole and its dependence on the human factor. Some aspects related to this have been covered recently by Rodrigues et al. (2011) as well as Sheikhmohammady et al. (2011). Practical aspects have also been discussed by van den Hove (2006), looking at applications in land use policy, Urbanavičienė et al. (2009), expanding applications to the field of real estate negotiations, and Koeszegi et al. (2011), looking at the technical aspects of

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synchronous and asynchronous negotiations. The theoretical model referenced in this paper has gone through a number of subsequent versions, each an improvement on its predecessor. A system based on this model would determine human agents' preferences, minimize bias in their behaviour and recommend solutions that are most likely to result in the maximization of their satisfaction with the final result of the negotiation process. Technological resources at our disposal are, at this point in time, insufficient in fulfilling the goal of endowing the system with some form of "understanding" of a human agent's behaviour. This is clearly outlined by existing research in the field such as that conducted by Herzog et al. (2007).

Reaching a point that would confirm our approach to be adequate would also require that any system based on the model be easily accepted and integrated by negotiators. Requirements in this sense have been discusses by Pommeranz et al. (2010). With this view the two defining factors of success are time, as described by Saorin-Iborra (2008), and return on investment, as discussed by Laury and Holt (2008).

A complete informational infrastructure, that would be able to provide a starting point and a proper testing base for our research, had to be developed as none of the existing solutions provided the flexibility required for our tests. The system had to be structured enough to enable validation of our hypotheses but also flexible enough to allow restructuring of long-run data structures in accordance with the requirements of each additional new version of the model. In order to add design flexibility, procedures within the model were divided in three major categories: follow, simulate, and assist. A system based on the model would perform three types of activities based on the categories mentioned above.

In a FOLLOW activity the system observes a negotiation process in order to gather information regarding possible reactions of human agents taking part in negotiations. Based on the type of access to the information available which is dependent on the specific conditions of the negotiation process under observation the system would have access to information from one or more of the parties involved. In a simulation information from all parties would be available, in a real-world scenario a single party's information would be accessible.

Behavioural profiles are generated based on data collected during FOLLOW activities. Autonomous agents whose characteristics are based on the observed behaviour of human agents are then used in the SIM activity where they are matched against each other in diverse theoretical scenarios in order to determine which agent performs best under a wide range of circumstances.

Lastly, the activity that aggregates all information matching the design of the entire model is called ASSIST. It includes all the components of a FOLLOW activity, utilizes the entire database generated through FOLLOW and SIM procedures and produces systematized information and advice that is designed to increase the economic value of the negotiation outcome, making the entire process more productive and efficient.

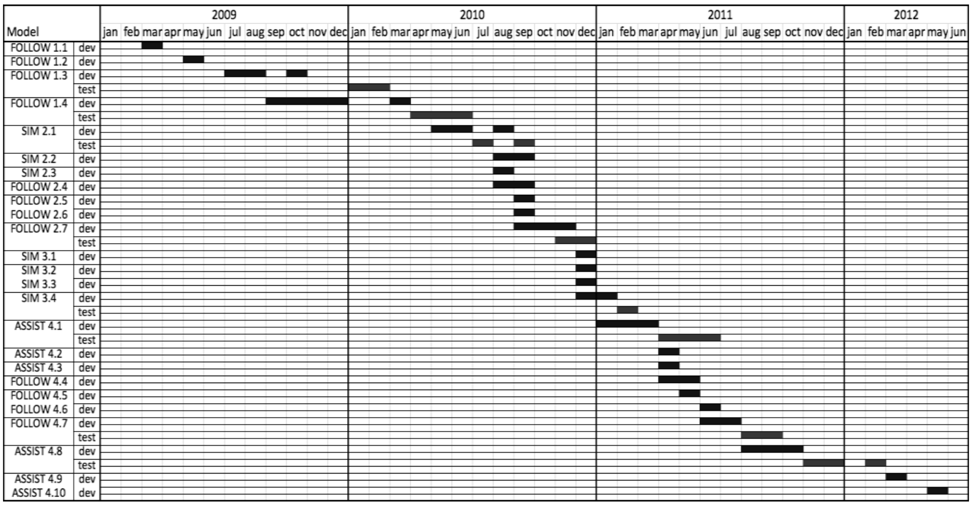

Figure 1. Model & System development Gantt chart.
Source: Nasulea C. current status of doctoral research.

1. ASSIST 4.1 MODEL

Taking into consideration the dimension of the data set obtained while testing the latest version of the SIM model, development of the first ASSIST model had to take into account constraints related to managing extremely large sets of data. While, before its implementation we were already looking at a database of over one billion records, projections related to the dimensional dynamics of the data set indicated exponential growth for each usage of a system based on any of the proposed models. This would undoubtedly have an impact on the technological costs of any of the systems and, consequently, also on the economic efficiency indicators related to the implementation of a solution.

The technical solutions we looked at were based on research carried out by Pugmire et al. (2009). These were focused mainly on the management of data in the scientific research and offering solutions that were better optimized for the specific case of the present research than other, better-known methods in the field of data management with the help of information technology.

Transitioning from a FOLLOW model to the first ASSIST model proved to be relatively simple, the latter being in fact an elaborate manifestation of the former, integrating the former unchanged and adding on supplementary steps and functions. The ASSIST 4.1 model integrates the most advanced FOLLOW model in its entirety and adds elements for the selection of the most adequate behavioural profile, in order to offer suggestions to the human agent regarding recommended actions that may be undertaken during the negotiating process.

In much the same way as a FOLLOW model, the current model records actions undertaken by the human agent, noting at the same time the differences between the positions

suggested by the autonomous agent on the basis of the selected behavioural profile and the actual choices made by the human agent.
In order to evaluate the results of the negotiation process, a final step was introduced in the model in order to collect subjective impressions, from the participating human agents, on the final results of the negotiation process. The extent/degree of satisfaction of the participants regarding the negotiating process had been recently confirmed as a viable means of measurement and hierarchical classification of the results in a study published by Curhan et al. (2010). The potential of this idea had been previously discussed by Gilletta (2009).

1.1 Testing the ASSIST 4.1 model

A number of 92 negotiations were carried out, in order to test the negotiation assistance solution based on the ASSIST 4.1 model. 12 negotiators, out of the 28 that had taken part previously in tests for FOLLOW models, took part in this series of tests as well.

14 new cases, created on the basis of those elaborated previously, were used. The objects of the negotiations were characterized by 2 to 11 factors and the negotiating processes could be carried out on the basis of the same 4 main variables that were used in the design of the previous cases. This time, the negotiators were allowed to create their own list of variables and to use it in the negotiating process. Generally, they have maintained the same variables used during case design. In 6 cases, negotiators have identified an additional variable, which they had the option to use in the negotiation.

The data obtained was added to the existing database, without carrying out new simulations in order to take into account the new behavioral profiles created. It was not necessary to recreate the demographic profiles for the negotiators, as none of them were taking part in a test session for the first time.

In 78 cases, an acceptable solution was reached by the parties involved, representing 85% of the total number of tests carried out. The results were ranked on the basis of the economic value of the final result obtained, but also on the basis of the satisfaction degree with the result, as indicated by the answers received when collecting post-negotiation subjective impressions from the participants. A new behavioural profile was created for each participation of each human agent in a negotiation test.

The value of the economic results obtained by human agents was analyzed in comparison with the medium values they had obtained in the absence of support from an information technology system. Taking into account the limited nature of the cases used and the orientation of the solutions towards distributive approaches, we have obtained mixed results in terms of statistical correlation.

In other words, some negotiators did better with the help of the system and others did worse when being assisted by the system. The sum of all the variations of the results obtained during the tests for this model compared to the results obtained in the FOLLOW tests, was close to 0, which is absolutely normal taking into account the distributive nature of the cases and their general inclination to lead to zero-sum game approaches.

Interesting results were obtained when calculating an obedience index and correlating it with the variation of results mentioned previously. The obedience index represented the percentage distance of the counter-offers launched by the human agent in comparison with the values suggested by the system on the basis of the selected behavioural profile. A direct correlation was noticed between the obedience index and the variation of the final result compared to the average of the results obtained in the non-assisted negotiations in more than 80% of the cases. The closer the offer of a human agent was to the recommendations of the system, the better the results obtained.

Human agents who did not take into consideration the recommendations, were generally those who got poorer results compared to those cases where they were not assisted by the negotiation support system.

Although a 0.79 correlation index was obtained on a limited data set and could be considered to be relatively low, taking into account the incipient phase of the model, it was enough to justify the development and the continuation of the tests on the same approach to the problem.

We have analyzed the time required to prepare each negotiation and we have reached the conclusion that improvement of data acquisition procedures is essential. Unfortunately, at the current stage of development in information technology, all the adaptations and improvements foreseen along these lines for the future variants of the model, will not be able to produce significant effects in reducing the time required for information processing.

1.2 Observations based on the ASSIST 4.1 test session

Designing the first version of an ASSIST model for the NSS allowed for the identification of significant constraints that were limiting the adaptive and evolutive capacity of the meta-model under development. The adaptation and evolution elements represented the starting points in designing the models in this research, solutions for the transformation of these models in real meta-models had to be sought, so that on their basis, the existence of systems capable of solving new problems and adapting to approaches that had not been encountered previously, would become a possibility.

After testing the first assistance model for negotiations we endeavoured to redesign it and to improve it, in order to introduce elements of self-adaptation as intended from the very beginning of the research.

Another two successive ASSIST models were developed and tested, however they did not prove to be viable and we eventually reached the conclusion that the element of variability, which could allow the adaptation of the system, was missing. The improvement of the solution of data acquisition for a better study of the behaviour of human agents would have been necessary, but, as we have seen previously on numerous occasions, technologically, we are limited, without having the possibility to push this limit far enough to be able to produce significant differences.

We have come to the conclusion that an external input was needed in order to create variations and modifications in the structure of the system. Because any implementation of an information system would not have had the capacity to invent new approaches or bring

new ideas that would alter the workflow we decided to expand the data acquisition component, allowing human agents to introduce new characteristics for existing variables, to offer and request feedback from the other participants.
We restructured the way human agents interact with the systems in a radical manner, adding on to the simple offer counter-offer approach and including the possibility to transmit supplementary information related to the parties' interests and BATNA.

In implementing the model we added new real-time visualization options, including access to analytic data related to the distance from the ultimate objective for the finalization of the negotiation and statistical analysis data related to the efficiency of an offer, evaluated from the point of view of the ensuing counter-offer.

2. HYPOTHESES

In order to verify the economic potential of the model we decided to analyze a few standard economic indicators in order to assess the feasibility of real-world implementations of our model's current version. We began our assessment with two simple hypotheses:

A. The economic benefits resulting from the use of a negotiation support system based on one of our adaptive models outweigh the costs of implementing the system.
B. Break-even occurs within the anticipated useful life of a negotiation support system.

3. ANALYSIS OF FINANCIAL EFFECTIVENESS AND EFFICIENCY

Several possibilities exist in order to assess the economic benefits of a solution and compare it to others. Because our model already includes a procedure whereby economic value is computed for each end result we decided to use the internal information already available in the implemented systems in order to make this assessment.

As stated previously, due to the nature of the cases and the simulation environment, increases in economic value of the end result could not be correlated with the use of the system as we had no control group where support was not given on the same specific cases referred to in the tests for the current version. To overcome this, we correlated the data from the obedience index with the economic value of the results in order to divide the behavioural profiles in two. There was a direct correlation between obedience and increases in end results at a correlation index of 0.92. The upper half on the obedience index scales, comprising the most obedient resulting profiles, saw increases in the majority of the cases we analyzed (~80%) while the lower half, the most disobedient profiles, usually fell on the losing side of the zero-sum game with lower economic values of their results (the same ~80%).

In order to finalize putting together the information required for analysis, costs for the development and implementation of the system were required. The lack of easily identifiable, billable costs, anchored in real-world market prices and quotations made it impossible to arrive at a verifiable design cost for the system, either for the current version of the model or for the overall work since the start of the project. There was simply not enough historical information available about other projects or other assimilated jobs that would allow us to come to a data-fundamented amount with regards to the cost of project design. This effectively limited our computation possibilities on the implementation cost to a simplified version, multiplying the number of programming hours with the average cost per hour in the industry situated at €18.5 / hour according to a 2010 report. By taking the 3 month period required for the development of the current model version and the dependent system and multiplying it with the number of work hours in the standard working week and the 3 people working on the period at the above mentioned rate we arrived at a cost of €26640.

Taking the economic reasoning even further we would have to also account for the additional time needed to feed data into the system. At an average data entry time of 2.4 hours, computed based on the time performance of each human agent over the 92 negotiations in the test base, and using the same rate per hour we would arrive at an average cost of €44.4 per negotiation process, per party and a total variable cost of €8170.

Due to the fact that our negotiation cases were all based on scenarios of average complexity where data was chosen arbitrarily, the overall difference in economic value between the end results obtained by the upper half (obedient group) and those obtained by the lower half (disobedient group) was quantified by the system at €12.3 million, much larger than the total costs of system implementation and combined hourly data entry rates. Our cases were mostly related to large investments in IT infrastructure, purchases of hardware and software, with values as high as €30 million.

Based on the data above we could easily confirm hypothesis A for the cases in our test group but we believe that a much more important conclusion should be drawn related to the components of the cost-benefit equation for this and any future assessments:

$$CB = TB - (IC + VC) \tag{1}$$

Where:

CB = cost benefit analysis result
TB = total benefits
IC = implementation costs
VC = total variable costs. Hours required for data entry at standard per hour rate.

Which elaborates to:

$$CB = (AB \cdot n) - (IC + AC \cdot n) \tag{2}$$

AB – average benefits per case
AC – average data entry costs per case
n – number of cases

Or:

$$CB = n \cdot (AB - AC) - IC \tag{3}$$

Which is essentially the standard break even cost equation, where CB = 0 (number of uses needed to for the benefits to cover the costs of implementing and using the system):

$$n = \frac{IC}{AB - AC} \tag{4}$$

The key point overlooked in our original hypothesis relates to the level of materiality of the cost benefit analysis. Final decision on whether an implementation of a system is worthwhile is closely related to the proportionality of the benefits obtained with the average value of the cases the solution is applied to.

$$FEff = {}^{CB}/_{ANS} \tag{5}$$

Which means that financial efficiency (FEff) is ultimately related to the proportion between cost benefit (CB) and average negotiation object size (ANS). In our particular case FEff was 0.615 resulting from the €12.3 million increase over an average negotiation object value of €20 million. That is a ~62% increase that can be correlated with the use of a NSS, which is significant by any standard.

Expanding the formula allows us to take the reasoning even further. We could in theory aim for a certain level of efficiency and determine the minimum number of iterations required in the use of the model in order for that level of efficiency to be met while dealing with negotiations in a particular field, with a particular average market value for the objects of negotiation.

$$FEff = \frac{n \cdot (AB - AC) - IC}{ANS} \tag{6}$$

$$n = \frac{FEff \cdot ANS + IC}{AB - AC} \tag{7}$$

On the counter part the same formula can be used to determine the minimum value of the average negotiation in industries where the number of iterations in a time period is predetermined or largely predictable.

Verifying our second hypothesis required the introduction of more information. The definition of anticipated useful life in our case can be assimilated with the average time between development phases of the model and corresponding systems. The useful life of a system ends when a new version is completed and fully implemented. By the end of 2011, based on the 7 versions tested to date, the anticipated useful life of a system was 3 months. Due to the evolving nature of the system this 3 month interval of substitution could be maintained well into the future. While based on our test case data which refers to big, highly productive investments the breakeven point occurs within the first iteration, in fact the implementation costs could be covered 4 times by the benefits of the first iteration, the situation will be quite different given a bigger sample and real world data.

CONCLUSIONS

The findings of this paper brought to light a set of correlations that, given the adaptive nature of the model and the fact that it deals with exactly the same kind of economic data, would be well suited for inclusion in the model itself. A future version of the model would most certainly benefit from an assessment of the level of materiality of expected benefits in relation to the object of the negotiation process in itself. Added to the already existing measurements of materiality within the negotiation turns of a negotiation process this could optimize costs in terms of time spent negotiating settlements in fields where such negotiations would not be worthwhile.

Because the model is constructed to change by absorbing feedback obtained through the application of the model's process, information regarding the useful life of each model version and its breakeven point will undoubtedly constitute a useful assessment tool for its future development. The current version of the model, and the model in general, have been found to be financially effective and, in the case of our test data, also materially efficient. Continued assessment of these indicators and a future track record of their measurements will help determine its continued practicality and keep its development on track towards maximizing negotiation results.

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