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TESTING ADAPTIVITY IN NEGOTIATION SUPPORT SYSTEMS

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Abstract
As part of a research project spanning over a period of 3 years, aimed at developing a succesful model for computer assisted negotiations, this paper looks at ways in which the adaptivity of the model can be assessed in accordance with the requirements of adaptive multi-agent negotiation processes.
Keywords: multi-agent negotiation, adaptive systems, negotiation support systems, NSS.

1. INTRODUCTION

Based on information from prior research conducted in the field of negotiation support systems (from hereon refered to also as NSS or simply "systems") we have begun designing and testing a model and corresponding NSS that would integrate ideas related to meta-modelling in multi-agent situations highlighted by those papers presenting the most promising results (Abrahams, Zeleznikow 2010; Chen et al. 2008; Pugmire et al. 2009). As time and the development of our model progressed the model was adjusted in order to take advantage of results published more recently by other researchers (Lau 2009; Koeszegi, Pesendorfer, Vetschera 2011; Bo, Li 2011; Sheikhmohammady, Kilgour, Hipel 2011; Rosenfeld, Kraus 2012). The model versions which form the basis of discussion for this paper also rely on unpublished results which are part of the global research project of this paper's coordinating author due for presentation and publication in 2012. The majority of the tests conducted on the model, in a similar way to what was done previously by other researchers, used land use rights (van den Hove 2006) or real estate (Urbanavičienė et. al 2009) scenarios as a basis. 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 on the next page.

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The theoretical model has gone through a number of subsequent versions, each adding onto the abstractization of the negotiation process. Given the subjective nature of the negotiation process (Gilletta 2009) and its dependence on the human factor (Curhan, Elfenbein, Eisenkraft 2010), a core component of the NSS is the procedure by which the system learns the behaviour of human agents. The system should determine their preferences (Laury, Holt 2008), minimize bias in their behaviour (Imai, Gelfand 2010) and suggest solutions that are most likely to result in the maximization of their satisfaction with the final result of the negotiation process. We have not tried, at any point in the research, to make the system "understand" subjective human behaviour. Technological resources at our disposal would be insufficient towards that end, as is clearly outlined by existing research in the field (Herzog, Esfeld, Gerstner 2007). Furthermore, the time frame required for potential real world use of the model was considered (Saorin-Iborra 2008 and Rodrigues et. al 2011) which meant the size of the variable set could only expand so far before it made use of the model entirely unattractive for negotiators (Pommeranz, Wiggers, Brinkman, Jonker 2010).

The idea of a self-adaptive meta-model required a flexible data structure. As none of the existing systems or models offered a solution that was as adaptive as that which was aimed for in our research, we had to develop a complete informational infrastructure that would be able to provide a starting point and a proper testing base for our research. The system had to be structured enough to allow for the validation of our hypothesies but also flexible enough to allow resturcturing of long-run data structures in accordance with the requirements of a changing model under permanent review. To facilitate this, procedures within the model were dvided in three major categories: follow, simulate, assist. The ensuing system would thus perform three types of activities based on these procedures.

As part of the FOLLOW activity the system simply observes a negotiation process in order to stockpile information regarding possible reactions of human agents taking part in negotiations. Based on the type of access to the information available which is dependant on the specific conditions of the negotiation process under scrutiny our system would have access to information from one or more of the parties involved.

Based on data collected during FOLLOW activities the system then generates behavioural profiles and corresponding autonomous agents whose characteristics are based on the observed behaviour of human agents. These agents are then used in the second, 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.

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The third activity, ASSIST, 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 chances of a more productive and efficient end result of the negotiation process. Efficiency, productivity and economic worthiness are measured in terms economic value and are matched against results recorded under similar circumstances without NSS support.

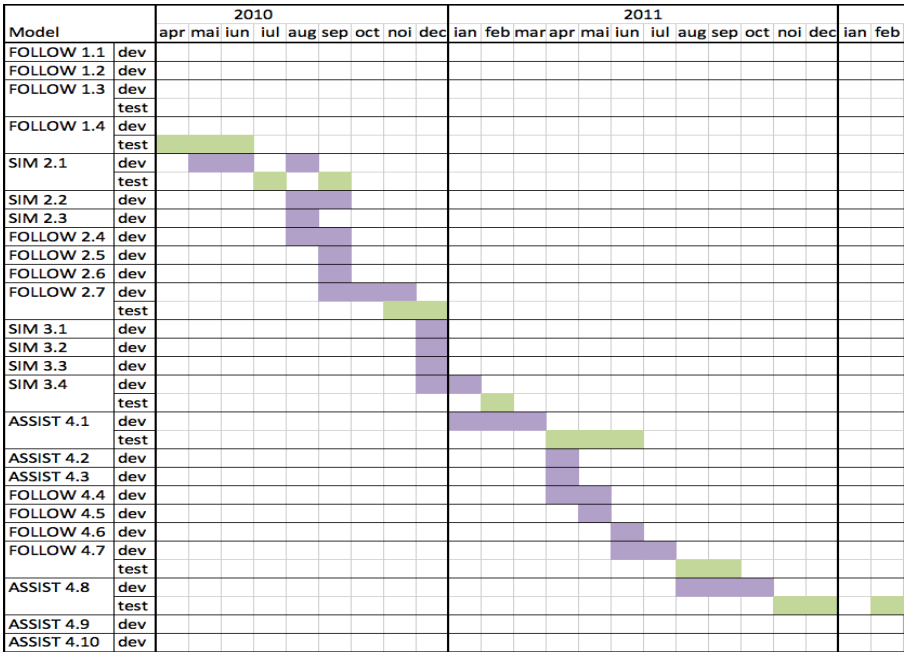

FIGURE 1 - SELF-ADAPTIVE META-MODEL DEVELOPMENT GANTT CHART. NOTABLE MODEL VERSIONS LISTED ON THE LEFT. VERSIONS WHICH HAVE UNDERGONE TESTING HIGHLIGHTED IN GREEN ON THE CHART.

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

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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 aproaches 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 aproach 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.

1. **ASSIST 4.8 MODEL**

This was the first model version to implement elements of evolutive self-adaptation. At this stage in the model's development the implementation of self-adaptation is limited to elements related to restructuring the order of participants' interventions in the negotiation, non-standard replies (as opposed to standard offer counter-offer replies), the possibility to interrupt the negotiation indefinitely, concession-based offer requests. A communication component for unstructured open-ended questions was included in the model, although practical implementations based on the model only mentioned the use of this type of interaction in the behavioural profile, as data relating to the question and the answer could not be interpreted automatically by the system. A simplified model diagram follows.

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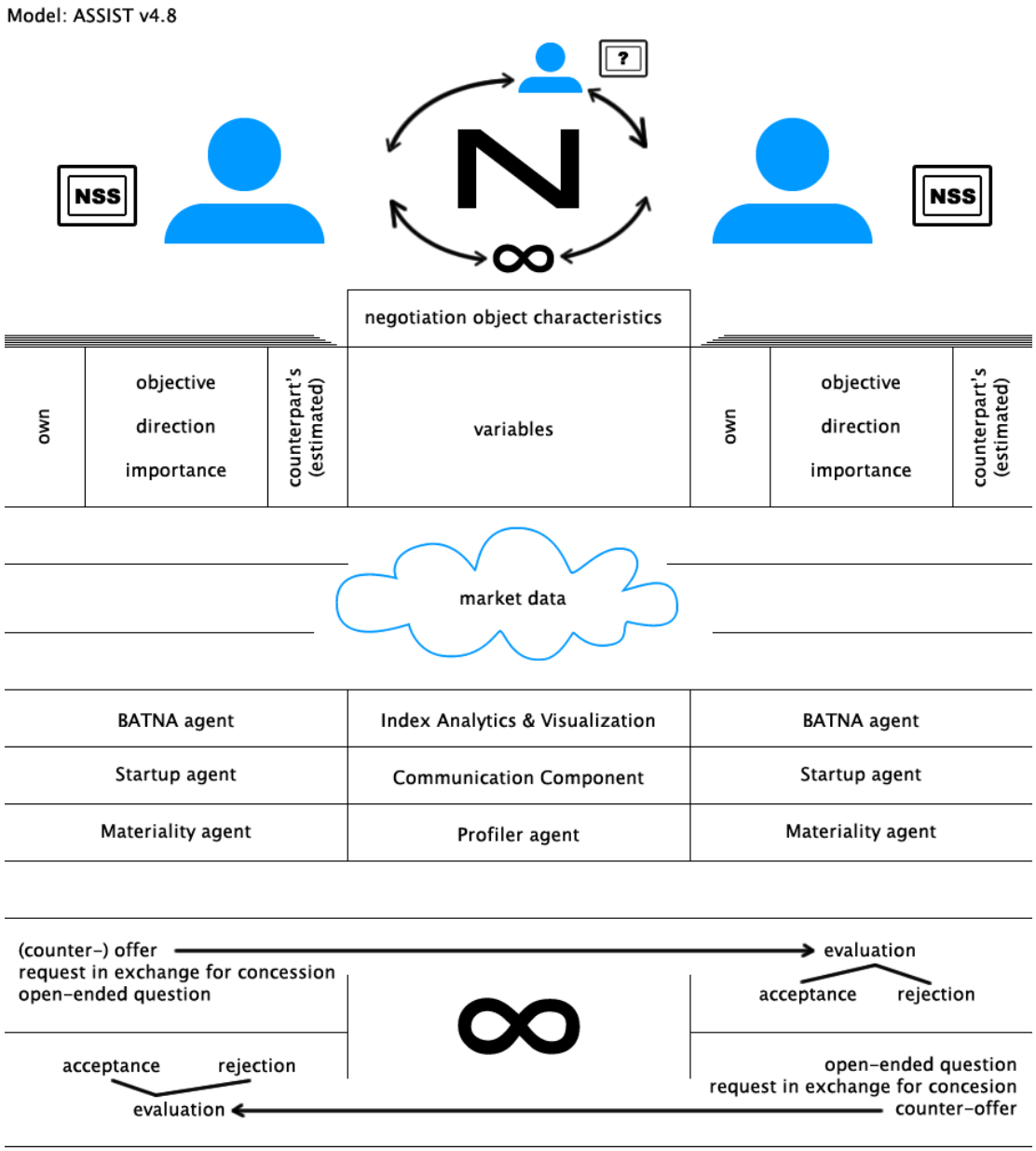

FIGURE 2 - SIMPLIFIED MODEL DIAGRAM FOR VERSION ASSIST 4.8

A real-time visualization component was developed and information about statistical indicators was included in the visualization output data. There is a correlation within the model between the feedback mechanism for available indicators and the modification of data being presented but this was not implemented in practice in any of the information systems at this stage. However, there is great potential for its implementation at a future date.

A trait recognition component for negotiation counterparts was included in the model and implemnted in the test system. While the lack of such a component did not appear to have a negative impact during

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tests on model 4.1, where all participants were known from previous tests and multiple behavioural profiles were available for each of them, proper adaptation of the system to a new, unknown negotiatior required the introduction of an initial version for a trait recognition component.

The ASSIST 4.8 model includes an independent, autonomous agent that follows the behaviour of negotiation partners, recognizing and continuously selecting the most appropriate behavioural profile from the database. In model 4.1 the independed agent charged with trait recognition only intervened before the start of negotiations attempting to profile the participants based solely on the information available at the beginning.

Model Workflow Steps	Repetitive
Set general negotiation parameters: number of negotiators, object, NSS support etc.	-
Ask negotiators to characterize the object of the negotiation.	-
Suggest other characteristics for the object of negotiation.	-
Finalize list of characteristics by way of final confirmation from human agent.	-
Ask negotiators to provide variables that will fall under debate during negotiation.	-
Have the NSS suggest other possible variables.	-
Finalize list of variables.	-
Ask negotiators to rank variables according to importance	-
Show variable pairs and ask negotiators to assign weights to the elements presented in each pair.	-
Ask negotiators to indicate desired end value (objective) for each variable.	-
Ask negotiators to indicate desirable direction of variable values	-
Ask negotiators to provide the same information about every variable for each negotiating partner (assumed values).	-
Ask for any available market data.	-
Initial data preparation by BATNA agent.	-
Startup agent	-
Profiler agent	-
Negotiation round	Yes
BATNA agent analysis of negotiation round data	Yes
Calculation and presentation of statistical end economic data and suggestions regarding recommended course of action alternatives.	yes
Pass data to Materiality agent in order to compute whether or not a new negotiation cycle should be initiated.	yes
Profiler agent to reanalyze behavioural profile adequacy	yes
Recompute relevant indexes and analytics components	Yes
Move to a new round of the negotiation process (if decided by human agent)	yes
Solution confirmation by negotiators	-
Final acceptance by all parties	-
Computation of economic value of negotiation results based on market data and negotiator preferences	-
Ask negotiator to complete end-result satisfaction survey	-
Store negotiator data as behavioural profile and proceed to simulation and analysis	yes

FIGURE 3 - ASSIST 4.8 MODEL WORKFLOW EXAMPLE

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The simulation component was integrated into the current version of the model in the same form detailed in the last independent simulation model SIM 3.4. Given the composition of the previous ASSIST 4.1 model which integrated the latest form of a FOLLOW model we can sepak of the ASSIST 4.8 model as being an integrated approach of our meta-model, comprising all elements from FOLLOW, SIM and ASSIST models. During the negotiation process the implemented information system carries out follow and assists tasks, recording the options of human agents taking part in the negotiation and providing real-time advice with regards to the most adequate approach needed in order to obtain the most effective end result.

During breaks between negotiations the system uses its resources in order to fill-in the simulation matrix matching each new behavioural profile against those already in the system.

In order provide a better understanding of the model, a workflow chronology example from a system implementation based on this version of the model is presented in Figure 3.

Mathematically, the core of the model revolves around the definition of variables used in negotiation. Each variable refers to a key aspect of a negotiation process, the two most common examples being price and delivery time. In our model, variable definition typically has the following elements:

VxO – objective for variable x. A target value is set for each variable defining the desirable end result for that variable

VxD – direction for variable x. Defines whether it is preferable for an end result to be smaller or larger on variable x.

VxI – importance of variable x. A relative rank for the variable computed by comparing variables against each other and assigning them weights.

VxOey – Another important component of the model is the use of estimates for each variable. This estimate represents the anticipated objective value on variable x for negotiator y.

VxM – market value at which negotiations usually settle on variable x based on independently available data. This is usually elaborated on and expressed in a price per unit format, coresponding to the characteristics defined for the object of the negotiation.

VxMod – modifier meta index based on supplementary information provided by the negotiator. This is computed in case the negotiator wishes to characterize the variable by way of supplementary information. This represents the base generalization tool warranting that we are in fact dealing with a “meta”-model.

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Offers exchanged in a negotiation process are evaluated based on the following formula, where VxOffer is the current level of the offer for variable x:

$$\mathrm{OV(i)} = \sum_{x=1}^{n} (V_x Offer - V_x O) V_x D \cdot V_x I \cdot V_x Mod$$

Offer Values (OV) below the objective will evaluate as negative results, those on the objective will be 0 and any gain in excess of the proposed initial objective will be a positive result.

The system's most basic comeback, where the behavioural profile indicates a simple counter-offer should be issued, is computed on the basis of the average amplitude recorded in the scenario where a certain behavioural profile had previously obtained the best possible result on a similar negotiation scenario. The simplified version of the model, where PSxA is the recorded amplitude of counter-offers for variable x in a previous scenario and VxOffer' is the value of the variable in the counter offer:

$$V_x Offer^1 = PS_x A(V_x Offer - V_x O) + V_x O$$

The value of the potential result requested through the counter-offer can therefore be evaluated simply as:

$$\mathrm{OV}(i^1) = \sum_{x=1}^{n} (PS_x A \cdot V_x Offer - V_x O) V_x D \cdot V_x I \cdot V_x Mod$$

The relevance of this evaluation, however is rather doubtful as counter-offers are usually bracketed around the target value even in negotiations with a small degree of oposition between conflicting interests. As a result counter-offer estimated values are often as overly-optimistic as the values of initial offers are unrealistic.

From the point of view of the adaptability of the model and its capacity to develop and evolve the model presents meta characteristics that could ensure its success, being able to integrate feedback from human agents in real time, having the possibility to add data, characteristics and variables and alter its own structure by altering multi-dimensional vectors used to characterize negotiation objects and variables involved in the process. At this stage the model and its implementations do not include adaptive mechanisms for BATNA agents and materiality levels but it does provide access to multi-dimensional characterization vectors, including those related to market data.

Information systems implemented on the basis of this model automatically compute a large number of statistical indicators and correlation indexes that had been previously analyzed by earlier versions of the

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research, starting with economic efficiency as it was defined in the earliest versions and ending with obedience indexes discussed in the latest versions. It contains verification procedures for the degree of correlation between elements of the data set that had not previously been analyzed. Where a decrease of the correlation index is found the impact of that factor is decreased in the selection process for an appropriate behavioural profile and, in theory, identifying a new correlation will lead to the selection of behavioural profiles that would otherwise have been dismissed as inappropriate.

2. HYPOTHESES

In order to assert the potential for adaptivity and continued evolution of the model we would set forth to test these hypotheses.

A. The presence of a meta index in the base formula of the model would allow negotiators to change the approach to the problem and come to improved overall solutions.

B. By letting a Profiler agent chose the apropriate course of action based on information in the knowledge base of simulations an obedient agent will obtain superior results in negotiations.

C. The introduction of a new type of negotiation case would result in a behavioural profile with significant differences from those already in the system. This behavioural profile would be applicable to its corresponding case and would be identified as such by the system.

3. TESTING THE ASSIST 4.8 MODEL FOR COHERENCE AND ADAPTIVE POTENTIAL

A number of 64 negotiation tests with 2 or 3 participants have been conducted. A total of 12 individual human negotiators took part in the tests. The set utilized for testing included 6 cases from the FOLLOW 1.4 model, 4 cases from the FOLLOW 4.7 model and 1 completely new case proposed by participants to the negotiation processes. Negoatiation objecs were characterized by between 2 and 27 factors and a the number of variables that were identified and used ranged from 4 to 12.

In 8 different instances the human agent acted only as an intermediary for the solutions recommended by the information system. In 7 of these cases the result obtained by the completely obedient human agent was greater in economic value than that obtained by the agent who did not adhere strictly to the advice of the negotiation support system. This, aggregated with other data from the obedience index, confirms hypothesis B with an error rate of around 10%. On average the degree of satisfaction was also greater in the case of obedient agents, but a sharper drop in satisfaction was observed for their negotiation partners, compared to the increase of their own degree of satisfaction. In other words final

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results were more satisfactory overall (for both parties combined) in cases where the human agent did not strictly follow the advice of the information system.

The correlation index between the obedience index and the final economic result was 0.8, very close to results obtained in tests for the ASSIST 4.1 model, then situated at 0.79.

Correlation indexes between profiling data colected previously for risk aversion (RA), intelligence (IQ) and cultural intelligence (CQ) were computed as well as for the standard demographic profile elements (age, gender). Correlations were identified between RA and economic result, at a weak index of 0.68, and between IQ and economic result, at an index of 0.91.

At the end of the test session, after simulations for new behavioural profiles were completed, the number of results in the database of the simulation component reached approximately 12 billion out of a maximum 16780329283 possible permutations.

No truly significant modifications of the model were recorded as a result of the negotiation processes in the test. Negotiators had the possibility to introduce modifications in the system but they chose not to. Lacking any changes we can only declare that hypothesis A remains unconfirmed. It might well be that in the presence of some changes inserted through the modification index mechanism described earlier in this paper improved solutions may be possible but this can only be verified through another test in which we might perhaps force participants to come up with model modifications, although in this case procedural bias would have to be evaluated.

Two behavioural profles had significant differences from those previously in the system. Both were generated based on the negotiation case proposed by the participants. The size of both data instances was aproximatively 80% larger than the average for previous data instances in response to the increased complexity of the case. The response patterns in both data instances had a much higher degree of non-linearity compared to other cases and relied much more on the use of open-ended questions and non-offer interactions between participants. The size of the data, the lack of linearity and difference in content allows us to state that hypothesis C is confirmed.

4. LONG-TERM OUTLOOK OF THE RESEARCH

Given the intrinsec evolutive characteristcs of the model, aimed for and designed for from the very beginning it's easy to understand that research on the model and the functionality of the resulting information systems is by nature a work in progress that needs to continue until all possible results are

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exhausted and the majority of correlations are analyzed. If the model proves to be viable in the long run, at least in theory, its possibilities would never be exhausted.

Through the design and modelling process and the results obtained in the tests we have confimed the possibility for such a meta model to be developed at the theoretical level.

The main constraint, and most important threat to the viability of such a meta-model and its implementation is related to the practicalities of data acquisition, observation of human agent behaviour and its digitization. Without technological solutions capable to perform the task of data acquisition in an automated manner the intervention of a human operator is required to mediate the system to human agent relationship or the human agent involved in the negotiation process is required to input all relevant data himself. The time required to perform all these operations makes the use of a growing, evolving system that requires more an more information to become increasingly difficult up to the point where it becomes completely unsound from the point of view of process efficiency or even borders on impossible. On the other hand, in order to obtain better and better results, to perform statistical tests and simulations on relevant samples the biggest possible data sets are required in order to enable the process methods to be refined striving for perfection.

The constraints listed above are the primary reason for the relatively limited number of tests performed on each model version but they are also the reason that compells the research to continue in order to expand the data sets, increase the relevance of results and confirm all findings to date.

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REFERENCES

Abrahams, B., Zeleznikow, J. - *A Multi-agent Negotiation Decision Support System for Australian Family Law*, Proceedings of the 2010 conference on Bridging the Socio-technical Gap in Decision Support Systems: Challenges for the Next Decade. IOS Press. Amsterdam, 2010. Pag. 297-308. ISBN: 978-1-60750-576-1

Bo, J., Li, J. - *A Multi-lateral Multi-issue Negotiation Protocol Based on Adaptive Genetic Algorithm and Its Application in Ecommerce*, 2011 International Conference on Energy Systems and Electrical Power (ESEP 2011), Volume 13, 2011, pag. 1380–1386

Chen, D.N., Jeng, B., Lee, W.P., Chuang, C.H. - *An agent-based model for consumer-to-business electronic commerce*, Expert Systems with Applications, Volume 34, Issue 1, 2008, pag. 469–481.

Management Research and Practice
Volume 7 Issue 1 / March 2015
ISSN
2067- 2462

Curhan, J.R., Elfenbein, H.A., Eisenkraft, N. - The Objective Value of Subjective Value: A Multi-Round Negotiation Study. Journal of Applied Social Psychology, vol. 40, nr. 3, pag. 690–709. 2010.

Gilletta, G.R. - *The Subjective Brain, Identity, and Neuroethics*, The American Journal of Bioethics, Volume 9, Issue 9, August 2009, pag. 5-13

Herzog, M.H., Esfeld, M., Gerstner, W. - *Consciousness & the small network argument*, Neural Networks, Volume 20, Issue 9, November 2007, pag. 1054–1056

Imai, L., Gelfand, M.J. - *The culturally intelligent negotiator: The impact of cultural intelligence (CQ) on negotiation sequences and outcomes*, Organizational Behavior and Human Decision Processes. Volume 112, Issue 2, 2010, pag. 83–98

Koeszegi, S.T., Pesendorfer, E.-M., Vetschera, R. - *Data-Driven Phase Analysis of E-negotiations: An Exemplary Study of Synchronous and Asynchronous Negotiations*, Group Decision and Negotiation, Volume 20, Number 4, 2011, pag. 385-410

Lau, R.Y.K. - *An Evolutionary Approach for Intelligent Negotiation Agents in e-Marketplaces*, Studies in Computational Intelligence, Volume 167, 2009, pag. 279-301

Laury, S.K., Holt, C.A. - *Payoff Scale Effects and Risk Preference Under Real and Hypothetical Conditions*. Handbook of Experimental Economics Results, Volume 1, 2008, pag. 1047–1053

Pommeranz, A., Wiggers, P., Brinkman, W.-P., Jonker, C.M. - *Social Acceptance of Negotiation Support Systems*, Proceedings of the 6th international conference on HCI in work and learning, life and leisure: workgroup human-computer interaction and usability engineering. Springer-Verlag Berlin, Heidelberg, 2010, ISBN: 978-3-642-16606-8

Pugmire, D., Childs, H., Garth, C., Ahern, S., Weber, G.H. - *Scalable computation of streamlines on very large datasets*, Proceedings of the Conference on High Performance Computing Networking, Storage and Analysis, Article No. 16, New York, 2009, ISBN: 978-1-60558-744-8

Rodrigues, S.A., da Silva, T.S., Pivotto, C., Girao, A., de Souza, J.M., Rocha, E. - *Integrating web and mobile knowledge management tools to improve negotiations*, 2011 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2011, pag. 3035 – 3040.

Rosenfeld, A., Kraus, S. - *Modeling agents based on aspiration adaptation theory*, Autonomous Agents and Multi-Agent Systems, Volume 24, Number 2, 2012, pag. 221-254

Saorín-Iborra, M.C. - *Time pressure in acquisition negotiations: Its determinants and effects on parties' negotiation behaviour choice*. International Business Review, Volume 17, Issue 3, 2008 pag. 285–309

Sheikhmohammady, M., Kilgour, D.M., Hipel, K.W. - *A Support System for Multilateral Negotiations*, 2011 IEEE International Conference on Systems, Man and Cybernetics (SMC), art. no. 6084207, October 2011, pag. 3476-3482.

Urbanavičienė, V., Kaklauskas, A., Zavadskas, E.K., Seniut, M. - *The Web-Based Real Estate Multiple Criteria Negotiation Decision Support System: A New Generation of Decision Support Systems*, International Journal of Strategic Property Management, Volume 13, Number 3, Versita, Warsaw, 2009

van den Hove, S. - *Between consensus and compromise: acknowledging the negotiation dimension in participatory approaches*, Land Use Policy, Volume 23, Issue 1, January 2006, pag. 10–17.

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