Group Decision and Negotiation 2014

GDN 2014

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GDN INFORMS Group Preface

Meetings of the Group Decision and Negotiation series aim to bring together researchers and practitioners from the humanities, social sciences, economics, law, management, engineering, decision science and computer science. These diverse areas are characterized by different paradigms, methods of inquiry and goals. But we focus on common challenges, including the problems faced by decision makers who must address tensions and conflicts through all phases of negotiations and group decision processes. These challenges require researchers to understand both the dynamics of independent entities and the consequences of their interactions. To provide practitioners with knowledge and tools, researchers construct models and systems that can not only aid decision makers, but in some cases undertake decision-related activities on their behalf.

As in all previous GDN meetings, Melvin F. Shakun has led us with his good spirit and a helping hand. He, together with Colin Eden, Keith W. Hipel, Gregory Kersten, Marc Kilgour and Floyd Lewis have helped us to adhere to the traditions that took root from the first GDN meeting in Glasgow, in 2000. Following memorable GDN meetings, including Vienna hosted by Rudolf Vetschera, Karlsruhe hosted by Christof Weinhardt, Montreal hosted by Gregory Kersten, Coimbra hosted by João Climaco and João Paulo Costa, Toronto hosted by Marc Kilgour, Delft hosted by Gwendolyn Kolfschoten, Recife hosted by Adiel Teixeira de Almeida, and Stockholm hosted by Bilyana Martinovski, the GDN 2014 meeting takes place in Toulouse and has been organized by Pascale Zaraté.

Marc Kilgour (Conference General Chair)

Melvin Shakun (Conference General Chair)

EWG-DSS
EURO Working Group on Decision Support Systems

The EWG-DSS is a Working Group on Decision Support Systems within EURO, the Association of the European Operational Research Societies

The main purpose of the EWG-DSS is to establish a platform for encouraging state-of-the-art high quality research and collaboration work within the DSS community. Other aims of the EWG-DSS are to:

- Encourage the exchange of information among practitioners, end-users, and researchers in the area of Decision Systems.
- Actively contribute to enlarge the networking among the DSS communities available and facilitate activities that are essential for developing international cooperation research and projects.
- Facilitate professional academic and industrial opportunities for its members.
- Support the development of innovative models, methods and tools in the field Decision Support and related areas.
- Actively promote the interest on Decision Systems in the scientific community by organizing dedicated workshops, seminars, mini-conferences and conference streams in major conferences, as well as editing special and contributed issues in relevant scientific journals.

The EWG-DSS was founded during a memorable EURO Summer Institute on DSS that took place at Madeira, Portugal, in May 1989. This Summer Institute was organized by two well-known academics of the OR Community: Jean-Pierre Brans and José Paixão. It counted with the participation of 24 (at that time) young researchers of 16 different nationalities. Most of them still continue nowadays to pursue their goals, working actively in their research areas.

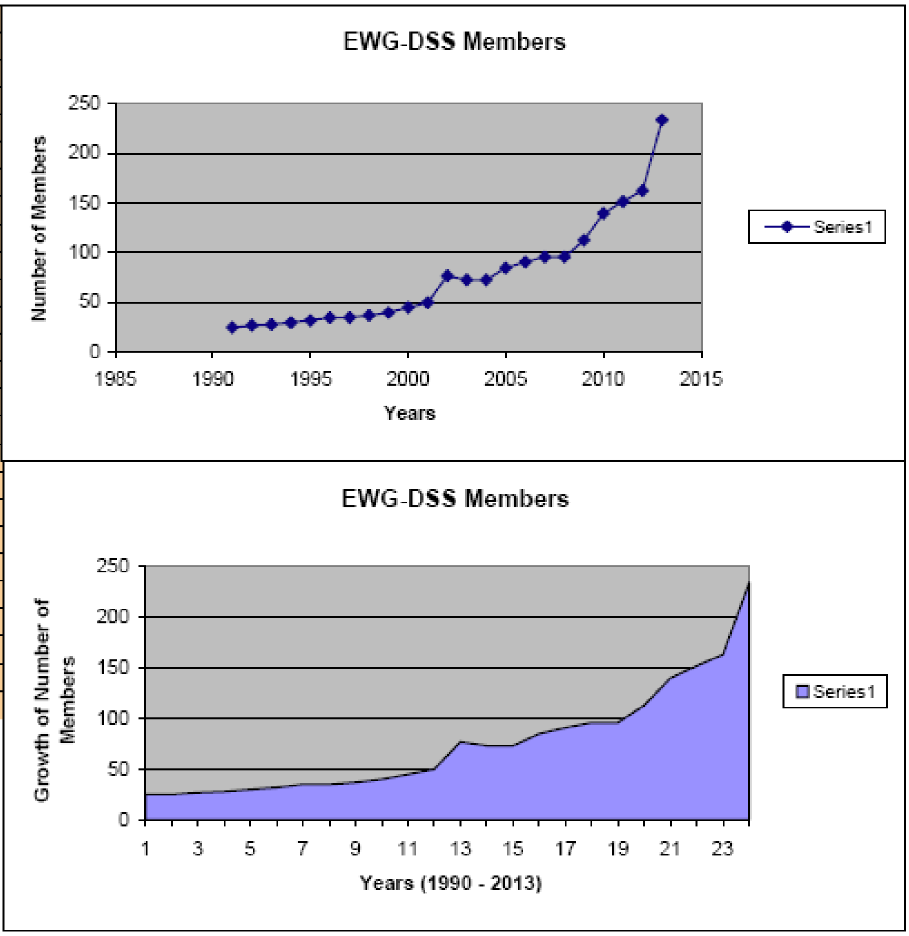
The number of EWG-DSS members has substantially grown along the years with members coming from all parts of the globe. Several research co-operations within the group members are leading to important contributions to the DSS field and joint journal publications.

Since its creation, the EWG-DSS has held annual Meetings in various European countries, and has taken active part in the EURO Conferences on decision-making related subjects.

Since 2007 the EWG-DSS has been managed by a Coordination Board. One of the aims of this coordination board is to better promote joint-work among the group members and to encourage more participation of the whole group in DSS related projects and events. In the period of June 2007 to January 2011 the EWG-DSS Coordination Board was composed by: Pascale Zaraté, Fátima Dargam and Rita Ribeiro. Since the beginning of 2011, the EWG-DSS Managing Board counts with the assistance of other three Board Members, namely: Jorge Hernández; Boris Delibašić; and Shaofeng Liu. From 2013 onwards, the board will count with two extra members: Isabelle Linden and Jason Papathanasious to better administrate the activities of the group, as well as to bring new ideas to it.

EWG-DSS EURO Working Group on Decision Support Systems
Number of Registered Members from 1990 up to 2013

#	Year :	Nr. Members:
1	1990	25
2	1991	25
3	1992	27
4	1993	28
5	1994	30
6	1995	32
7	1996	35
8	1997	35
9	1998	37
10	1999	40
11	2000	45
12	2001	50
13	2002	77
14	2003	73
15	2004	73
16	2005	85
17	2006	91
18	2007	96
19	2008	96
20	2009	113
21	2010	140
22	2011	152
23	2012	163
24	2013	234



EWG-DSS Members from 1990 to 2013

The EWG-DSS in the GDN-2014

The growing demand for collaborative approaches of decision making and decision support, keeps us aware of the importance of getting in contact with professionals and colleagues, working in the area of Group Decision Making and Negotiation.

In the GDN-2014, the EWG-DSS group participants will take the opportunity of this conference, which main theme is “Group Decision Making and Web 3.0”, to exchange new ideas with the participants coming from the GDN Section of INFORMS group, concerning topics and approaches of the relative areas. Some of those areas are: applied game theory, experiment and social choice, cognitive and behavioral sciences as applied to group decision and negotiation, conflict analysis and resolution software, specifically group decision support systems (GDSS), negotiation support systems (GDNSS) and more generally decision support systems (DSS), artificial intelligence, and management science as related to group decision-making.

Fatima Dargam (Conference Co-Chair)
Rita Ribeiro (Conference Co-Chair)

The GDN 2014 conference is the 14th conference of the INFORMS Section on Group Decision and Negotiation. It is organized jointly with the EURO Working Group on Decision Support Systems (EWG-DSS).

While in the past GDN members participated in the DSS meetings and vice versa, this is the first joint conference which allows to strengthen the relationships between these two organizations leading to the enhancement and enrichment of research projects in individual and group decision support, negotiation and auction support, as well as the design of systems and agents capable of active participating in individual and group processes and in negotiations.

The GDN 2014 proceedings have two volumes, one Springer volume and one local volume. In this local volume, 48 selected papers including long late papers, short papers, and posters are published. The keynote abstracts are also presented.

GDN 2014 included a Doctoral Consortium, held June 10th 2014, that offered PhD students a possibility to present their work and discuss the orientations of their future researches with other PhD students but also with mentors.

This conference is widely international. The authors, submitting their papers, come from the following countries:

Australia	2	Japan	7
Austria	5	Netherlands	5
Belgium	4	Poland	6
Brazil	10	Portugal	9
Canada	19	Romania	1
China	10	Senegal	1
Egypt	1	Serbia	6
Finland	1	Spain	7
France	20	Sweden	5
Germany	12	Taiwan	3
Greece	6	Tunisia	2
India	3	Turkey	2
Iran	1	United Arab Emirates	3
Ireland	2		
Israel	5	United Kingdom	9
Italy	2	United States	4

We are grateful to the individuals and institutions making this conference a successful event. We would especially thank the program committee members of GDN 2014 as well the mentors participating to the Doctoral Consortium for their scientific support; the Toulouse 1 Capitole University, the IRIT laboratory, the INPT SAIC, Conseil Régional Midi Pyrénées , the Paul Sabatier University for their financial supports; the EURO Working Group on DSS, the EURO Association, the GDN section and the INFORMS for their assistance.

Pascale Zaraté (Conference Program Chair)

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PART I

Keynote Presentations

Alain Lempereur

lan B. Slifka Professor and Director, Graduate Programs in Coexistence and Conflict Member of the Executive Committee, Program on Negotiation at Harvard Law School The Heller School for Social Policy and Management, Brandeis University, Waltham, MA 02454-9110 (USA).

Abstract: ***It takes more than two to tango for responsible negotiation***

When in 1942 Antoine de Saint-Exupery wrote "Each one of us, alone, is responsible for everyone," he laid down a foundation for responsible negotiation. Often, a common definition of negotiation makes it a game where each party is only responsible for his or her own personal success, independently of the other's outcome. Such an instinctive approach rarely leads to a good choreography by both. Win-win theories have expanded sole responsibility to a dual responsibility where at least one side strives for both sides' success, making it more likely for the negotiation dance to flow. The agency theory extended this responsibility through even more complex two level-games, where each side does not simply care about success at the negotiation table but also behind the table. It looks like for the negotiation dance to work, it must even explore stakeholders beyond the table. This conference will examine a broad responsibility approach and explore what the implications are for people, problems and process in negotiation.

Denis Bouyssou

Research Director, CNRS, Lamsade, University Paris Dauphine, Paris, France.

Abstract: ***Should we use bibliometric indices to evaluate research?***

Higher education and research are often seen as affecting in a cru-cial way the economic performances of nations. Indeed, most countries devote a significant part of their resources to finance higher education and research institutions. Hence, we should expect that there is a growing tendency to evaluate and monitor their performances. Obvi-ously, their very nature makes this task difficult and complex.

We have recently witnessed a flourishing of evaluation agencies and a growing use of bibliometric indices of various kinds to evaluate indi-vidual scholars, departments, projects or universities.

The aim of this presentation is twofold. We will first outline the type of problems that may be encountered when evaluating research activities using standard bibliometric indices. We will then show how the classical tools provided by decision theory may be useful to an-alyze the theoretical properties of such indices. Our conclusion will be that some frequently used indices, such as the h-index, have rather undesirable properties.

This talk will be based on joint research with Thierry Marchant, Ghent University, Belgium.

Adiel Almeida

Professor at the Federal University of Pernambuco, Brazil.

Abstract: ***Resolving Evaluation of Criteria by Interactive Flexible Elicitation in Group and Multicriteria Decision Aid***

In Group Decision related to Multicriteria problems the facilitation process demands contributions in the intersection of many topics, such as: analytical constructs, cognitive process of individuals and the social interaction process of a group of decision makers (DMs). Evaluating weights of criteria is one of the most relevant issues in multicriteria decision problems with group decision aggregation process, particularly for additive models. There are many studies on eliciting scaling constants or weights of criteria based on DMs' preferences, resulting in elicitation procedures available. Amongst them, the tradeoff procedure is considered to have the strongest theoretical foundation, although many inconsistencies have been found by applying this procedure in experimental studies. The basic reasons for that are related to the cognitive process of individuals and to the excessive effort demanded by such procedure. In group decision these inconsistencies may increase with the number of DMs. It is interesting to observe that the strongest axiomatic foundation of that elicitation procedure allowed realizing those inconsistencies. Therefore, we may argue that a facilitation process without analytical constructs may have many inconsistencies, which may not be perceived yet.

Following an overview of the several elicitation procedures and formal techniques for addressing them, an analysis is carried out on resolving evaluation of criteria by interactive flexible elicitation. It is shown a manner to overcome inconsistencies in previous procedure, by introducing the concept of flexible elicitation. Two main benefits are achieved by using flexible elicitation. It is easier for the DM to make comparisons of consequences based only on preference rather than on indifference relations and the information required from the DM is reduced to a minimum. This procedure is built into a group decision support system and applied in a few practical situations.

Hannu Nurmi

Professor at Department of Political Science and Contemporary History University of Turku, Finland.

Abstract:

Reflections on Fairness and Rationality of Voting Rules Over the past decades a wide variety of voting rules have been introduced, criticized, modified, adopted or rejected. In contradistinction to many other institutions, voting rules are typically designed with a more or less clear motivation. One often mentioned motivation is that they should tease out the will of the people. In other words, the outcomes of voting rules, when applied to the opinions of the people, are expected to represent the collective will. Riker (1982) called this the populist view of democracy. It is not difficult to see that at least prima facie this view leads to problems since the very existence of several non-equivalent voting rules suggests that either the people have many minds even in cases where the expressed opinions remain stable, or at least some rules { perhaps all of them { simply aren't up to the task of uncovering the collective will.

Often the rules are motivated by fairness considerations. For example, it is argued that every individual ought to be given an equal a priori weight in determining the voting outcome. Similarly, it may be insisted that each voting alternative should be equally treated in the voting process, or that additional support should never harm an alternative. After a brief historical excursion, we summarize a host of voting rules in terms of various desiderata stemming from different conceptions of fairness and collective) rationality. Our special focus is on how relevant are the theoretical results in guiding the choice of a voting rule.

The rule-desideratum- combinations undoubtedly give us information about what may or may not happen when various rules are being applied. Choosing rules with as many advantages as possible would be one plausible way of proceeding. Another way is to approach the problem of disclosing the will of the people in a more straight-forward manner: start from a hypothetical situation involving a given number of voters and alternatives such that the will of the people can be unambiguously determined. An obvious candidate for such a situation is one where all voters have identical rankings over candidates. Then obviously this ranking can also be viewed as the will of the people.

Often we are looking for rules that - given the observed individual preference rankings - give a social ranking. This approach would then suggest looking for the collective ranking that is closest to the observed individual rankings in a sense of some distance measure defined for pairs of profiles. Varying the hypothetical situations of “consensus" and the metric used in measuring distances between observed preference profiles and the hypothetical ones, one can define voting rules in a

natural way. It turns out that many existing rules can be characterized in this manner, i.e. can be given a distance rationalization.

An aspect of voting rules that has not been given the amount of attention is deserves is power. This is not to say that voting power per se has not been extensively studied. It has (see e.g. Holler and Nurmi, eds. 2013), but the typical setting focused upon involves binary agendas and a sequence of ballots. Yet, a glance at the role that the agenda-setter plays in determining the voting outcomes reveals that the a priori voting power indices may give a misleading picture of the determinants of voting outcomes.

Rationality is often invoked as a criterion for selecting a voting rule. Indeed, the result nowadays known as the Condorcet Jury Theorem can be (and has been) seen as a powerful argument for the one-person-one-vote principle in dichotomous voting contexts. However, it is based on rather stringent assumptions regarding voter competence. In expert decision making other types of problems emerge, e.g. is it possible to maximize the probability of correct decisions by assigning different weights on experts reflecting their competence?

Maximizing group competence leads to judgment aggregation problems and to the fundamental question of the proper scope of voting in deciding complex issues. Of particular importance here are epistemic paradoxes. We shall briefly discuss some of these.

References

[1] Holler, M. J. and Nurmi, H., eds. (2013) Power, Voting, and Voting Power: 30 Years After. Berlin-Heidelberg: Springer Verlag.

[2] Riker, W. H. (1982) Liberalism against Populism. San Francisco: W.H. Freeman.

PART II

Negotiation Processes

Multidimensional analysis of negotiation processes

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Abstract. Negotiation processes involve a substantive, a communication and an emotional dimension. These dimensions have been analyzed mainly in isolation of each other. We introduce an approach to consider all dimensions simultaneously and present an empirical study on interactions between these dimensions. Results indicate a strong linkage between communication behavior, emotions and agreement, while connections to the substantive dimension of the negotiation process are weaker.

Key words: negotiation; process; utility; communication; emotions

1 Introduction

Negotiations can be analyzed from many different perspectives [7, 17]. Over the last decades, two main streams of research dealing with negotiation processes have emerged. One stream is mainly concerned with the substantive side of negotiations. This stream can perhaps best be exemplified by the concept of negotiation analysis [10, 14]. This stream sees a negotiation mainly as a sequence of offers and counteroffers, leading to an agreement in terms of the substantive issues. It is predominantly concerned with economic criteria like efficiency and the payoff obtained by each negotiator – measured, for example, in terms of utilities.

In parallel, a more behaviorally oriented stream of negotiation research has emerged, which emphasizes the role of communication in negotiations [5]. Researchers in this stream have developed classification schemes for communication acts [8] and phase models of negotiations [1], which explain how communication content changes over time, and how these different communication contents affect the outcome of a negotiation. The main outcome dimension in this stream of research is whether a negotiation reaches an agreement at all.

More recently, researchers have begun to consider emotions as yet another dimension of the negotiation process [4]. This research has uncovered different patterns in the development of emotional behaviors over time in successful and failed negotiations and thus has contributed to our understanding how emotions shape processes and outcomes of negotiations.

These different dimensions of negotiation processes, and their related outcome measures, are also clearly reflected in the design of existing negotiation support systems (NSS). Many systems like for example `Inspire` [6] follow an economic approach and provide tools to elicit utility functions, evaluate offers, and other decision support tools. Other systems like `Negoisst` [12] also implement features to enhance communication quality by, e.g., allowing for the explicit classification of messages as "question" or "offer". NSS that explicitly consider emotions, given the relative novelty of this perspective, are yet to be developed [2].

However, the interactions between these dimensions of negotiation processes, and their mutual influence on related outcome measures, have only rarely been studied. The emotional dimension so far has been studied mostly in isolation. Analyses of the substantive dimension of negotiation processes often ignore the content of communication besides the exchanged offers. Studies that focus on the communication dimension of negotiation processes consider emotional or substantive content similar to any other type of content. At a quite cursory level, content of the emotional dimension is assigned to categories like "affective persuasion" [1] and content of the substantive dimension to categories like "single-issue offer", "multi-issue offer" [1, 9], or "concession" [8, 9].

One reason for this lack of multidimensional analyses might be the lack of a unified framework for negotiation processes, which is needed to study these dimensions simultaneously. In the present paper, we apply such a framework, the standardized interpolated path analysis (SIPA) approach [18] to conduct an exploratory analysis of the interactions between different dimensions of the negotiation process. The remainder of this paper is structured as follows: In the subsequent Section 2, we give a brief overview of methods employed to measure the different dimensions of the negotiation process as well as the SIPA approach. In Section 3, we present some exemplary results and Section 4 evaluates the outcomes of this study and provides directions for future research.

2 Methods

Our analysis is based on the SIPA approach [18]. This approach provides a consistent representation of negotiation processes, in which a variable number of offers is made at varying points in time. To make processes comparable, SIPA interprets each offer or message as one observation of a continuous time process, i.e. one assumes that the underlying variables characterizing the process change continuously over time. Linear interpolation between observations is used to approximate values at fixed points in time, e.g., each quarter of the negotiation. This provides a comparable representation of the processes of all negotiations in a study.

This approach can be applied to all dimensions of the negotiation process. To model the substantive dimension, each offer is characterized by the utilities it provides to the party making the offer, and to the opponent. Consequently, the process is modeled by four utility values. Similarly, the communication process can be represented by interpreting the fractions of different types of communication acts in total communication as state variables, which are interpolated at fixed time intervals. The emotional dimension of negotiation processes can be represented by a dimensional model of emotions [11], which distinguishes the two bipolar dimensions of valence (pleasure vs. displeasure) and activation (activation vs. deactivation). The following sections present the results of an illustrative application of these concepts to data gathered in negotiation experiments.

3 Data

We use data from a previous negotiation experiment with the NSS `Negoisst` conducted in 2011 [13]. In total, 234 students (i.e. 117 dyads) from four European universities participated in this experiment. The bargaining case used was about a joint venture negotiation.[1] The system recorded all offers made, so data on the substantive level of the negotiations was readily available. Following the SIPA approach, utilities to both sides from offers of both sides were interpolated at the end of each quarter of each negotiation. From this utility data, we calculated joint utilities as the sum of utilities to both parties, and contract imbalance as the difference of utilities. Both values were calculated for offers from both sides, and then averaged across sides to obtain one unique measure for each negotiation at the end of each quarter.

To measure communication content, all messages exchanged were assigned to content categories by independent coders following the content analysis approach of [15]. These content categories in turn were mapped to the four basic categories introduced by [8], which consist of two action-oriented types of creating and claiming value, and two information-oriented types of communication providing integrative and distributive information. The relative shares of these four categories in each message were used as status variables of the negotiation, and interpolated again at the end of each quarter of each negotiation.

To measure the emotional content of messages, a free-sorting task was used [16]. Messages were first sorted according to their emotional similarity by groups of untrained raters, who were not familiar with the research questions involved. From these ratings, a two dimensional emotional score was obtained using MDS. By considering messages located at extreme values, the dimensions obtained through MDS could readily by identified with the theoretical emotional dimensions of valence and activation.

4 Results

Before we present results on the relationships between different process dimensions of the negotiation, we give a brief overview of the impact of these dimensions on negotiation outcomes. As already explained, we describe the process

[1] Further details about the case, the experiments and experimental conditions can be found in [3, 13].

at the substantive level by the outcome-related dimensions of joint utility and contract imbalance. Therefore, we focus on agreement as the main outcome dimension.

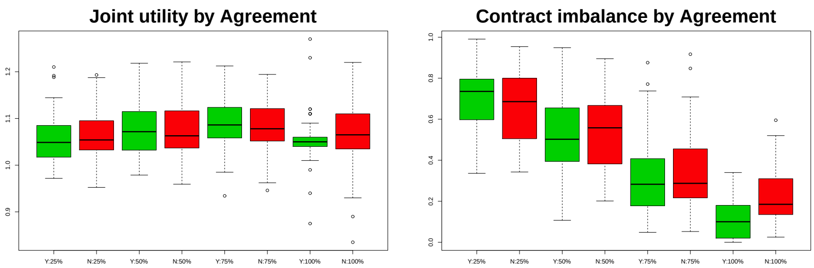

Fig. 1. Joint utility and contract imbalance over time in successful (Y) and failed (N) negotiations

Figure 1 shows the development of the two substantive process dimensions over time in failed and successful negotiations. There is a considerable decrease in joint utility over the last quarter of (successful) negotiations, indicating the classical negotiator's dilemma that aiming for high outcomes and thus efficiency at the same time reduces the chances of reaching an agreement at all. In general, patterns of failed and successful negotiations over time are very similar, the only significant difference according to a non-parametric Wilcoxon test exists in the last quarter of negotiations with respect to contract imbalance ($W = 2091, p < 0.1\%$).

Figure 2 presents a similar analysis for content categories. Content categories referring to information show a very similar pattern in failed as well as successful negotiations, while content categories related to strategic action are significantly different already in the first quarter of the negotiation. As could be expected, successful negotiations are characterized by more value creating behavior, while failed negotiations exhibit a significantly higher level of value claiming throughout the whole negotiation process.

Finally, the development of the two dimensions of emotions is shown in Figure 3. Failed and successful negotiations drift significantly apart in the last half of the negotiation in the valence dimension. There is also a significant difference in the activation dimension during the last quarter.

4.1 Substantive and communication dimensions

Table 1 shows the correlation coefficients between the substantive dimension (joint utility and contract imbalance) on one hand, and the usage of the four types of communication on the other hand. Surprisingly, providing integrative information does not have a positive effect on joint utility, to the contrary, the

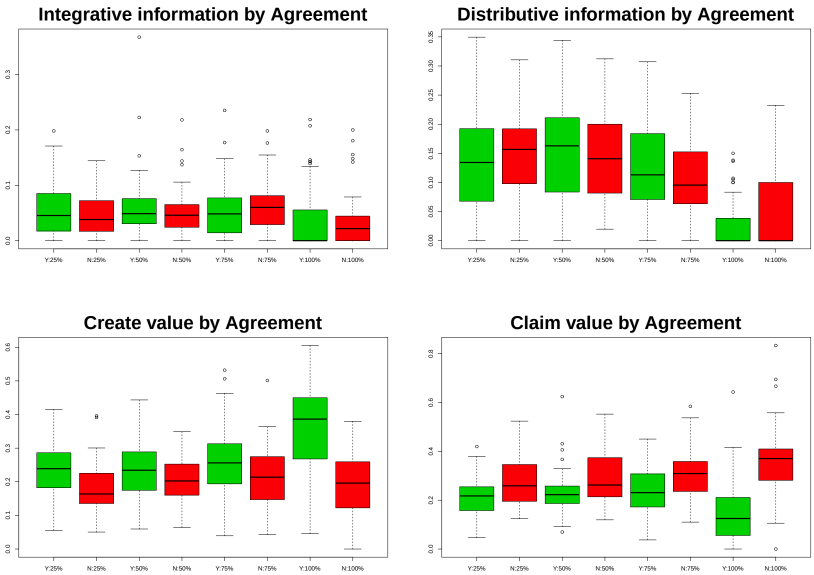

Fig. 2. Communication content categories over time in successful (Y) and failed (N) negotiations

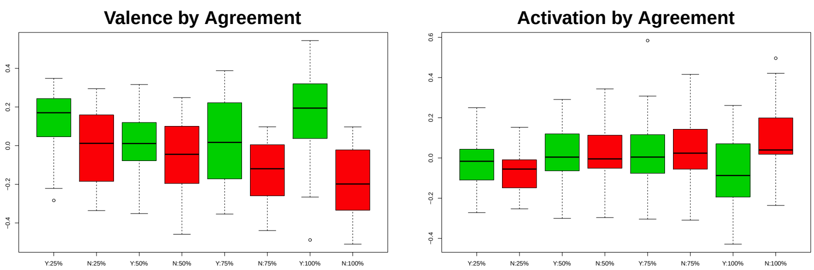

Fig. 3. Emotion dimensions over time in successful (Y) and failed (N) negotiations

	Joint utility				Contract imbalance			
Progress	25%	50%	75%	100%	25%	50%	75%	100%
Create value	0.006	*0.204	**0.249	-0.067	0.044	*-0.219	-0.022	**-0.260
Claim value	0.070	-0.145	*-0.216	-0.062	0.015	0.119	0.017	0.166
Integrative info	0.096	-0.068	*-0.230	0.079	-0.044	0.018	0.136	*-0.192
Distributive info	0.069	0.003	0.033	0.022	-0.118	-0.046	**0.287	0.159

Table 1. Correlations between substantive behavior and communication

only significant correlation is a negative one (in the third quarter of the negotiations). As could be expected, there is a positive relationship between distributive information and contract imbalance at least in some parts of the negotiations, and a negative relationship with integrative information.

However, joint utility is an accumulated value resulting from all concessions and offers made during the negotiation up to the point at which joint utility is measured. If one instead considers actual value creation within each quarter of the negotiation (i.e. joint utility at the end compared to joint utility at the beginning of each quarter), there is no significant correlation between any communication category and actual value creation.

4.2 Communication and emotions

	Valence				Activation			
Progress	25%	50%	75%	100%	25%	50%	75%	100%
Create value	***0,567	**0,427	***0,672	***0,695	0,203	-0,132	-0,180	0,068
Claim value	***-0,442	***-0,620	***-0,553	***-0,463	-0,044	0,226	*0,338	*0,330
Integrative info	-0,187	0,045	-0,154	0,002	0,121	-0,094	*0,301	0,250
Distributive info	*-0,288	0,065	-0,098	-0,253	0,074	0,169	0,110	0,095

Table 2. Correlations between communication and emotions

Table 2 shows the correlations between the usage of different communication categories and the two emotional dimensions. There is a strong correlation between action-oriented communication and the valence dimension of emotions in the expected direction: Value creating communication is strongly related to positive emotions, value claiming behavior to negative emotions.

These correlations do not imply a causal relationship. In fact, causal relationships could work in both directions: Receiving communication which claims value could lead to negative emotions, and negotiators expressing negative emotions could be more likely to use value claiming strategies. To disentangle these effects, we analyzed the two parties separately and calculated the correlations between the emotions of one party, and the communication behavior of the same party as well as the opponent.

The results of this analysis are shown in Table 3. While there are significant effects for both parties, the correlation between emotions and communication behavior is stronger within the same party than with the opponent's communication behavior. This makes an influence of emotions on communication behavior more plausible than vice versa.

5 Conclusions, limitations, and outlook

In the present paper, we have provided a first glimpse at the relationships of different dimensions of negotiation processes to negotiation outcomes and to each

	Valence				Activation			
	Own communication							
Progress	25%	50%	75%	100%	25%	50%	75%	100%
Create value	***0,533	***0,367	***0,569	***0,616	0,178	-0,020	-0,090	-0,086
Claim value	***-0,339	***-0,480	***-0,506	***-0,433	-0,064	0,160	0,176	**0,299
Integrative info	*-0,187	-0,047	*-0,201	-0,039	-0,015	0,002	**0,245	0,089
Distributive info	**-0,258	0,072	-0,017	*-0,218	0,005	0,004	0,004	0,050
	Opponent's communication							
Create value	0,174	0,131	***0,330	*0,212	0,038	-0,123	-0,158	0,158
Claim value	*-0,213	***-0,311	*-0,209	-0,144	0,018	0,108	**0,274	0,069
Integrative info	-0,053	0,099	0,011	0,041	0,147	-0,103	0,139	0,163
Distributive info	-0,135	0,013	-0,113	-0,084	0,081	*0,201	0,146	0,052

Table 3. Correlations between emotions and own/opponent's communication

other. Two main results of this analysis stand out: Firstly, communication behavior and emotions both are strongly related to success and failure of negotiations. This result of our study adds to the evidence of this well documented effect. Moreover, our multidimensional approach enabled us to reveal that the effect of emotion and communication behavior is even stronger than that of substantive behavior on the same outcome dimension.

The more surprising results of this analysis concern the relationships between the different dimensions. We found only comparatively weak links between communication and substantive behavior of negotiators. In contrast, the link between communication and emotions is much stronger, in particular the link between a negotiator's own communication and his or her emotions. In evaluating these results, it should be kept in mind that quite different approaches were used to measure both variables, so these strong correlations cannot be interpreted as an artifact of measurement methods.

However, the empirical study we have presented here still has some limitations. It is based on a student sample, which raises some questions of generalizability. Furthermore, we only used one case, which was specifically designed to induce a rather high level of conflict, so the relationships between dimensions in more integrative negotiations might be different. Thus, our present analysis is only a first step toward exploring the relationships of the different dimensions of negotiation processes in wider contexts. The SIPA method proofed to provide a useful framework to establish a common process representation not only across different negotiations of a study but also across dimensions. More elaborate analysis methods can then be used to provide a clearer picture of negotiation processes. In particular, consistency between the substantive, the communication and the emotional dimensions could be another important factor leading to success or failure of negotiations and deserves consideration in future research.

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Does Team Satisfaction Really Improve Negotiation Performance?

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Abstract. Negotiations in organizations are often performed by teams which try to maximize their own negotiation outcomes. Prior research has already shown that the composition of a team influences the team performance. Scholars have, for example, analyzed the impact of team size, hierarchy, or gender on negotiation outcomes. However, to date, no study has considered group-level constructs that mainly result from teams' composition, such as team satisfaction. Against this background, our study examines the impact of team satisfaction on teams' individual and joint negotiation outcomes. Furthermore, we analyze possible determinants of team satisfaction by drawing on diversity factors in teams' composition. Among others, our results show that team satisfaction has a negative impact on the teams' individual outcomes. Furthermore, we found team size to be a determinant of team satisfaction.

Keywords: team negotiations, team satisfaction, group-level construct, negotiation outcome

1 Introduction

Negotiations occur daily in organizations [1]. For example, the purchase department negotiates with supplier firms, the sales department negotiates with customers, and the human resources department negotiates with potential employees [2]. In many cases, negotiations are so complex that they need to be performed by organizational teams [e.g., 3, 4]. Thereby, the negotiation teams usually try to assert their own interests and try to maximize their own negotiation performance [e.g., 5]. This is especially the case as supervisors often evaluate the negotiation performance to determine a team's rewards and sanctions [6].

Scholars, both from an organizational and management research background, have already analyzed several aspects that can increase teams' performance, such as rewards, task autonomy, communication frequency, and, especially, team composition [7, 8, 9, 10]. For example, Eisenhardt and Schoonhoven [11] discovered that team tenure has a positive impact on companies' sales growth. Wiersema and Bird [12] showed that age heterogeneity in a team has a negative impact on companies' turnover. Moreover, Smith et al. [13] found that functional heterogeneity has a negative effect on teams' performance due to the associated coordination and control costs.

In the area of negotiation research, a few initial studies have also considered team performance. These studies mainly refer to the composition of negotiation teams [e.g., 14, 15], but do not consider group dynamics resulting from teams' composition, such as competition, conflict, or cooperation. However, group dynamics seem to be important since existing research has shown that they impact team performance. For example, Halevy [16] showed that conflict in negotiation teams harms negotiation outcomes. Similarly, Keenan and Carnevale [17] as well as Crump [18] discovered that intragroup conflict and disunity in the team have a negative impact on negotiation performance. It is widely accepted that teams with high consensus perform better than teams with dissents.

Interestingly, however, some researchers have argued that this relationship is the other way around. More concretely, Jehn [19], Amason [20], and Pelled et al. [21] found that disagreements and conflicts can be beneficial to task performance, especially for non-routine team tasks, such as negotiations. This is because teams with a higher level of conflict tend to be more receptive to other positions and perspectives [22]. Following this argumentation, it can be assumed that team satisfaction decreases a team's performance since satisfied team members tend to share the same opinions and therefore do not find the best solution to a problem for which there is more than one possible solution.

Although, negotiation research has recently paid more attention to team negotiations and team composition [e.g., 4, 15, 16], no studies have yet analyzed the impact of team satisfaction on negotiation outcomes. The main purpose of our study is thus to examine the impact of team satisfaction on negotiation performance (individual and joint outcomes). Moreover, we are interested in identifying group-specific variables that lead to team satisfaction. In this context, we draw on Levi's [23] group diversity concept.

In the following, we summarize the existing literature on team satisfaction in order to derive our hypotheses. We subsequently report on a large-scale negotiation experiment and describe our results. Finally, we discuss our findings' implications as well as the limitations of our study.

2 Conceptual Framework and Hypotheses

To date, organizational and management research has mainly analyzed the team satisfaction construct in the context of work teams [e.g., 9, 24, 25]. Most of these studies describe team satisfaction as team members' happiness with their team partners and their willingness to continue working with them [e.g., 26, 27]. Mason and Griffin [25] added to those definitions by specifying team satisfaction as the group-level construct of individual-level job satisfaction. This implies that team satisfaction is an attitude that the whole team shares – Klein and Kozlowski [28] call it a "shared-unit property."

Some scholars assume a positive relationship between team satisfaction and team performance, arguing that team members who share a common purpose and have a high level of consensus work more effectively [e.g., 29]. However, other conflict management studies have argued that disagreements and conflicts are beneficial to team task performance [19], as the consideration of contradictory positions leads to more open-minded problem solving in the team [e.g., 19, 22]. Furthermore, conflicts lead team members to reflect more deeply on their own opinions [30] and may increase the amount of information considered during the decision making process [31]. Following this stream of research, it can be assumed that satisfied teams with a low level of conflict perform worse than teams with a higher level of conflict, as they are satisfied with considering only a few opinions without keeping other positions in mind. Since, in the negotiation context, existing studies have shown that the group decision quality is positively related to a high level of within-group information processing by taking an extensive amount of information into account [32], we agree with this second line of reasoning and propose the following hypotheses:

H_{1a}: *Team satisfaction has a negative impact on the individual outcome of negotiation teams.*

H_{1b}: *Team satisfaction has a negative impact on the joint outcome of negotiation teams.*

As mentioned above, we are also interested in identifying team satisfaction's determinants. For this purpose, we once more draw on organizational and management research findings. Many of these studies analyzed team satisfaction as a dependent variable in conjunction with the factors of team composition, such as the team size as well as the team members' skills, organizational tenure, and perception of group norms [e.g., 24, 33, 34]. Referring to Levi [23], all these composition factors can be classified into three types of team diversity: Demographic diversity comprises, for example, gender, age, and nationality. Psychological diversity refers to team members' cognitions and behaviors, including their values, perceptions, or personality. Finally, organizational diversity relates organizational variables that affect a team member's status in the organization. Organizational variables are, for example, hierarchy, tenure, and team size [23].

In order to conduct a comprehensive analysis of the possible determinants of team satisfaction and to further capture all three mentioned diversity types, we selected three diversity variables from each type that seemed adequate for and illustrative of our empirical study. In this context, gender was used as a demographic diversity measure, friendship was used as a psychological diversity variable, and team size was used as an organizational diversity variable.

With regard to gender, existing studies have shown that the more homogenous the team is, the higher its members' satisfaction [e.g., 35, 36]. This is because homogenous teams are more likely to have a common understanding of information as well as the objectives of a team task [34]. Furthermore, homogenous team members identify more strongly with each other. This leads to a trusting atmosphere within the team, which promotes communication [34]. Concerning friendship, researchers determined that friendship between team members has a positive impact on their satisfaction level [e.g., 37, 38]. Grey and Sturdy [39] explained that friendship in an organization or a team is based on shared interests, trust, and intimacy. Moreover, Shah and Jehn [40] discovered that friends stick together, identify with each other, and communicate more frequently. Regarding team size, research has shown that the team members' satisfaction decreases when the team size increases [e.g., 41, 42]. Furthermore, Bright and Parkin [43] argued that, in larger teams, information processing takes longer and that the multiplicity of opinions and positions entails the risk of team separation.

While the mentioned studies mainly considered team members' satisfaction in terms of job or task satisfaction – i.e. as an individual-level construct – we hypothesize the mentioned variables' impact on team satisfaction as an organizational-level construct. This is possible because we assume that team satisfaction is a "shared-unit property", and thus that the individual and the organizational construct share the "same content" [e.g., 44, 28]. We consequently developed the following hypotheses:

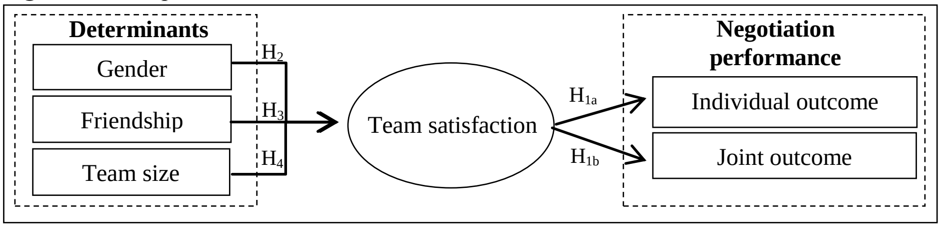
H_2: Gender homogeneity in a team has a direct and positive impact on team satisfaction.

H_3: Friendship in a team has a direct and positive impact on team satisfaction.

H_4: Team size has a direct and negative impact on team satisfaction.

Figure 1 gives an overview of our conceptual model and the derived hypotheses.

Figure 1. Conceptual model



3 Empirical Study

3.1 Methodology

We conducted a large-scale negotiation experiment with student groups in order to analyze the impact of team satisfaction on individual and joint negotiation outcomes and to identify team satisfaction's determinants. Our sample consisted of 230 students who participated voluntarily in our business-to-business negotiation experiment. Team size ranged from two to three persons and the teams were either assigned to the role of the buyer or the role of the seller. The 90-minute negotiations took place in a closed online chat room. At the end of the negotiations, the student teams may or may not have reached agreement on six negotiation issues.

Furthermore, we developed a short survey that was sent via email to every participant on the day of the negotiation experiment. The students had to answer the questionnaire individually. The survey consisted of six questions relating to the participant's satisfaction with the negotiation team, the participant's evaluation of friendship, as well as questions concerning team size and gender. A total of 204 students – at least two of the same team – filled out the online survey.

Gladstein's [24] scale was used to measure the team satisfaction. We adapted the items, which were based on a 5-point Likert scale, to the negotiation context. Even though we measured team satisfaction on the individual level, it could be aggregated to the group level since the intra-class correlation coefficients (ICC(1) = .068; ICC(2) = .699) achieved good results [45]. Therefore, we could denote our team satisfaction construct as a "shared-unit property" [28]. As the Cronbach's Alpha and the factor reliability were higher than .80, the construct was considered valid and reliable. The team satisfaction's determinants (friendship, team size, and gender) were measured directly. Regarding friendship, participants had to indicate whether they had "friends" or "no friends" within the team, team size had to be specified as either "2 members" or "3 members" and the gender options were either "male team," "female team," or "mixed team." We created dummy variables in order to integrate these variables into our conceptual model. A value of 1 was assigned to the "friends" option and 0 otherwise, a value of 1 was assigned to "2 members" and 0 otherwise, and a value of 1 was assigned to "homogenous teams" (comprising "male team" and "female team") and 0 otherwise.

3.2 Results

We tested our hypotheses with structural equation modeling using SPSS AMOS 21. As dummy variables were used to determine team satisfaction's determinants, we first estimated a measurement model without dummy variables to assure external consistency. Thereby, we achieved satisfactory fit indices (X2/d.f. = 1.79; GFI = .982; AGFI = .945). We then estimated the model using one dummy variable at a time to further assure external consistency.

As hypothesized, our results showed that team satisfaction has a negative impact on the individual negotiation outcome (-.143, p = .091), but no significant impact on the joint negotiation outcome. Following Hildebrandt [46], we considered a significance level of .10 acceptable. Therefore, H_{1a} is supported, whereas H_{1b} is rejected. Furthermore, we found that team size has a significant impact on team satisfaction (p = .05). The standardized coefficients showed a positive significant impact (.174) of the dummy variable "2 members", whereas the corresponding variable "3 members" had a negative significant impact (-.174) on team satisfaction. We could not find any significant effects for the team satisfaction determinants gender and friendship. Thus, H_4 is supported, whereas H_2 and H_3 are rejected.

4 Discussion

The objective of our study was to analyze the impact of team satisfaction on a negotiation team's performance. Considering team satisfaction a group-level construct and referring to existing conflict research, we hypothesized that team satisfaction has a negative impact on the individual and joint outcomes of a negotiation team. Furthermore, we wanted to identify determinants of team satisfaction. Therefore, we included group diversity variables, such as friendship, gender, and team size in our analysis.

Our results confirm the negative impact of team satisfaction on the individual negotiation outcome. However, it did not have a significant impact on the joint negotiation outcome. Furthermore, we found team size to be a determinant of team satisfaction. More concretely, our results indicate that a team size of two members positively impacts team satisfaction, while teams of three negatively impact it. No significant results were found for friendship and gender.

Since our study is the first to analyze team satisfaction in a team negotiation context, our results have important implications for the negotiation practice and future research. In general, we learned that practitioners should consider team satisfaction when composing a negotiation team. It is important for practitioners to know that a lack of team satisfaction positively influences negotiation team's performance, since a higher level of conflict leads to contradictory opinions of team members as well as to a more open-minded problem solving by keeping other positions in mind. However, our results do not implicate that team members should be at odds with each other. Instead, it suggests that team members should be changed from time to time to prevent too much habit and sympathy from forming in the team. Moreover, as our results indicate that team satisfaction is higher in teams with two members, practitioners should rather use teams of three.

Although our study offers first insights into the analysis of team satisfaction in team negotiations, it also has some limitations. First, we only considered three diversity variables as possible team satisfaction determinants. It would be interesting for future research to take further team composition variables, such as hierarchy, education or cultural aspects, into account. Second, we measured friendship directly and included it as a dummy variable in our conceptual model. Future research could analyze friendship more comprehensively by adapting, for example, Nielsen et al.'s [47] friendship scale to the negotiation context. Third, our teams consisted of only two or three members. It would be also interesting to analyze larger teams.

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MARS – a hybrid of ZAPROS and MACBETH for verbal evaluation of the negotiation template

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Abstract. In this paper we discuss the issue of evaluating the negotiation template using the tools of the Verbal Decision Analysis (VDA). We propose an algorithm that employs the key notions of ZAPROS and MACBETH to elicit the negotiator's preferences over some reference solutions by means of pairwise comparisons. Linguistic evaluation is used to define the preferences. By hybridizing these two approaches we are able to determine the cardinal scores of the potential negotiation packages based on verbal judgements defined by the negotiators.

Keywords: preference analysis, negotiation offer scoring system, verbal decision making, ZAPROS, MACBETH.

1 Introduction

The recent experimental research on multiple criteria decision making (MCDM) shows that in the vast majority of situations the decision makers (DM) describe their preferences qualitatively, using verbal or linguistic categories [15]. Similarly, reference points are defined vaguely using imprecise and qualitative categories. However, quantitative methods and models are widely used in negotiation support to elicit the negotiators' preferences and build a negotiation offers scoring system [7; 14], such as SAW [6] or TOPSIS [16]. The quantitative approach is of great importance in the negotiation analysis, since it allows to perform asymmetric and symmetric analyses of the negotiation process, for instance: measuring the scale of concessions; visualizing the negotiation progress; searching for the improvements in the contract negotiated by the parties; finding the arbitration (fair) solution of the negotiation problem or producing general conclusions of descriptive nature [5; 8]. Therefore a question arises, vital from the viewpoint of the negotiation analysis, whether it is possible to combine, in negotiation support, verbal or linguistic approaches (requiring simple and intuitive judgments) with the classic quantitative ones (operating with cardinal scoring systems), to provide the negotiators with a support tool both easy to use and highly useful.

In this paper we focus on developing the first component of such a negotiation support tool, i.e. a negotiation offers scoring system that can be used for the negotiation template evaluation. The approach we propose is based on the fundamental notions of the ZAPROS method [9], which allows DMs to define their preferences verbally and provides a straightforward but effective method for analyzing the trade-offs between the alternatives using selected reference alternatives only [9]. This method, however, results in an ordinal ranking and allows incomparability cases between the alternatives to occur, thus it cannot be directly applied to build a negotiation offers scoring system. To overcome these limitations we hybridize ZAPROS with the MACBETH approach [2; 3; 4]. The elements of the MACBETH algorithm applied in our method allow to determine the cardinal scores for the alternatives and to identify potential inconsistencies in defining the preferences by the negotiators in the classic ZAPROS approach. It also extends the classic ZAPROS functionality by allowing the DMs not only to declare if one alternative is preferable over another, but also to specify verbally by how much it is better or worse. The scoring system obtained this way makes it possible to conduct a sophisticated symmetric and asymmetric negotiation analysis mentioned before.

The paper is organized as follows. In section 2 we briefly present the basic notions of ZAPROS and MACBETH that are used later in section 3 to define our own hybrid algorithm for scoring the negotiation template, defined by means of the reference alternatives. A short example is provided in section 4 to describe the detailed calculations. In section 5 we summarize the key concepts of our approach and discuss future work on the development of MARS.

2 Basic methodology

2.1. VDA and ZAPROS

The methods from the ZAPROS (an abbreviation of the Russian words: Closed Procedures near Reference Situations) family [9; 10] are very well known within the Verbal Decision Analysis (VDA) paradigm [11]. The key concept of the VDA approach is to allow the DMs to express their evaluations and preferences in a verbal and ordinal form (for instance using expressions such as: 'more preferable', 'less preferable' or 'equally preferable'), which seems stable and reliable according to the results of psychological experiments. This linguistic, non-numerical form should not be transformed into a quantitative form in any arbitrary way [12]. Techniques based on VDA do not use quantitative information on the importance of criteria, but only verbal estimates, and no quantitative operations are performed on them. Hence, all operations are clear and understandable to decision-makers [1].

As regards ZAPROS, preference elicitation consists in comparisons of pairs of hypothetical alternatives differing in performance with respect to two criteria only; each alternative consists of the best evaluations for all the criteria but one. The results of these comparisons are transformed into the so-called Joint Ordinal Scale (JOS), which is subsequently used to compare real decision-making alternatives [1].

The ZAPROS procedure consists of [13]:

1. Determination of the evaluation scale for each criterion considered in the decision-making problem.
2. Pair-wise comparison of the hypothetical alternatives, each with the best possible values for all the criteria but one, using the ordinal scale (more preferable, less preferable, and equally preferable).
3. Construction of the JOS, which is a complete rank order of the hypothetical alternatives with the best evaluations for all the criteria but one.
4. Pairwise comparison of the actual decision-making alternatives using the JOS and construction of a partial order on their set.

2.2. MACBETH

The MACBETH (an acronym of Measuring Attractiveness by a Categorical Based Evaluation Technique) approach was developed in the early 1990's [2; 3]. It was devised as a response to the question 'how to build a value scale on a finite set of elements, in a way both qualitatively and quantitatively meaningful, without forcing a DM to give direct numerical representations of preferences and involving only two elements of the set for each judgment required from the DM?'. Hence, using the MACBETH method, a DM provides information about the comparison of two elements (alternatives, criteria) of the analyzed set at a time, first by giving an ordinal judgment as to their relative attractiveness/importance and second – if they are not deemed to be equally attractive/important – by expressing a qualitative judgment about the difference between their attractiveness/importance using six semantic categories: 'very weak', 'weak', 'moderate', 'strong', 'very strong' and 'extreme' or – if the DM is unsure of the size of the difference – a succession of them [4]. Next, the numerical value scales for the considered alternatives with respect to each criterion, as well as a weighting scale, are built on the basis of the DM's semantic judgments using linear programming. The overall value scores of the alternatives that reflect their attractiveness with respect to all the criteria are calculated by additively aggregating the single-criterion value scores.

The MACBETH procedure is as follows [4]:

1. Pairwise comparison of the importance of the criteria, as well as the attractiveness of the alternatives according to each criterion.
2. Solution of the linear programs corresponding to all the comparisons conducted.
3. Transformation of the scales obtained for the alternatives and the scale constructed for the weights into 0-100 scales. In the case of the criterion weights, values from the 0-100 scale should be normalized so that their sum is equal to 1.
4. Calculation of the weighted sum of the scores of the alternatives with respect to each criterion.

The MACBETH technique is very popular worldwide. It has been used in many public and private applications such as: human resources management, strategic town planning, environmental management, resource allocation, credit scoring, etc. [4].

3 MARS - the preference elicitation algorithm based on the ZAPROS and MACBETH methods

From the point of view of the negotiation analysis and evaluation of the negotiation template ZAPROS has one serious drawback, namely a relatively low comparison power – incomparability of alternatives is almost unavoidable. Thus, the resulting final solution may be unsatisfactory for the DM (negotiator). Moreover, the outcome is represented on a graph showing the preference relations and ranking only which might be insufficient for the negotiators expecting numerical information on differences between the global attractiveness of the alternatives since this type of information would help them to evaluate the concessions made by the parties in the subsequent negotiation rounds.

Taking these shortcomings into account we propose a new approach called MARS. The acronym MARS stands for: ***M***easuring ***A***ttractiveness near ***R***eference ***S***ituations. It is based on two methods: ZAPROS and MACBETH, and aims at obtaining a complete ranking of the alternatives with scores measured on an interval scale.

Let $F=\{f_1, f_2,..., f_n\}$ be a finite set of n evaluation criteria (issues); X_k a finite set of possible verbal values on the scale of criterion $k=1,2,...,n$, where $|X_k|=n_k$; $X=\prod_{k=1}^{n} X_k$ a set of all possible vectors in the decision (negotiation) space of n criteria; and $A=\{a_1, a_2,..., a_m\}\subseteq X$ a subset of X describing alternatives considered.

The MARS procedure consists of the following four steps:

1. Determination of the evaluation scale for each criterion considered in the negotiation problem.
2. Pairwise comparison of the hypothetical alternatives from $Y \subset X$, each with the best resolution level for all the criteria but one (the ZAPROS-like approach), and the ideal reference vector (with the best evaluations for all the criteria), using the following semantic categories (the MACBETH-like approach): 'no', 'very weak' (d_1), 'weak' (d_2), 'moderate' (d_3), 'strong' (d_4) 'very strong' (d_5) and 'extreme' (d_6). The difference in attractiveness between vectors is expressed by 'd_i to d_j', $i \le j$. The comparisons are performed using M-MACBETH software, which automatically verifies their consistency and offers suggestions to resolve possible inconsistencies.
3. Solution of the linear program corresponding to the comparisons performed (using the MACBETH approach and M-MACBETH software) to obtain the scores from the 0-100 scale for the elements compared, i.e. to form the Joint Cardinal Scale (the ZAPROS-like approach).
4. Ordering the alternatives with respect to the ideal alternative.
   Let us substitute the resolution levels in each vector describing the alternative from the negotiation template by the corresponding scores from the 0-100 Joint Cardinal Scale. For each alternative the distance L_i from the ideal alternative is defined by the formula:

$$L_i = \sum_{k=1}^{n} (100 - p_{ik}) \;, \qquad (1)$$

where p_{ik} is the score from the 0-100 Joint Cardinal Scale substituting the assessment of alternative a_i according to criterion f_k.

The final complete ranking of the alternatives is constructed according to the distance values L_i in ascending order.

4 Example

Let us assume that in the buyer-seller negotiations, the seller decides to formalize and evaluate the negotiation template to obtain the negotiation offers' scoring system. The following negotiation issues are discussed: f_1 - unitary price (EUR), f_2 - payment conditions (days), f_3 - returns policy. The negotiation template is defined by the numerical values for f_1 and f_2, and linguistically for f_3 by means of the following sets of the reference salient options:

- Price: {30, 40, 50, 60, 70},
- Payment: {7, 14, 21},
- Returns: {Very Poor (VP), Average (AV), Very Good (VG)}.

The scoring system for feasible negotiation offers can be created out of various combinations of the salient options (5 × 3 × 3 = 45 different packages). We assume that the seller considers f_1 to be the benefit issue, and f_2 to be the cost one and that he is able to evaluate the options not only by (1) declaring the occurrence of preferences (one option is better than another) but also by (2) describing verbally the strength of his preferences (by how much one option is better than another). Such a template definition is required by step 1 of the MARS algorithm. It should be noted, however, that the definition (1) is sufficient to apply MARS in the analysis of the negotiation template.

Next, the seller compares pairs of the reference alternatives (defined according to the recommendations derived from ZAPROS) using various semantic categories (defined in the classic MACBETH approach). Figure 1 presents pair-wise comparisons required by step 2 of the MARS procedure, performed by the seller using M-MACBETH software. Note that in Fig. 1 only the hypothetical reference alternatives (each with the best resolution level for all the criteria but one) and the ideal alternative (with the best evaluations for all the criteria) are compared. According to the fundamental assumptions of ZAPROS, based on these comparisons, the basic options are ranked according to the increasing concessions their require. Using the MACBETH's linguistic scale allows us to assign cardinal scores to each option, which reflects the scale of concessions required, when the ideal option in the package is replaced by the option under consideration. Table 1 presents the scores on the 0-100 scale obtained as a result of applying step 3 of the MARS procedure.

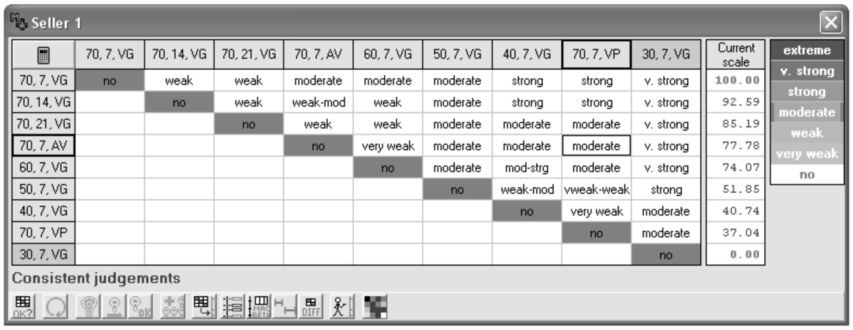

Figure 1. Comparisons made by the seller

Table 1. Joint Cardinal Scale

Resolution level	70	7	VG	14	21	AV	60	50	40	VP	30
Score from the 0-100 scale	100,00	100,00	100,00	92,59	85,19	77,78	74,07	51,85	40,74	37,04	0,00

Examples of L_i distances to the ideal alternative for each package that can be built within the negotiation template as well as their ranks are given in Table 2.

Table 2. Examples of feasible packages, ranks and distances L_i to the ideal alternative

Criterion value			**Score from the scale 0-100**			**Distance**	**Rank**
f_1	f_2	f_3	p_{i1}	p_{i2}	p_{i3}	L_i	
70	7	VG	100	100	100	0	1
70	14	VG	100	92.59	100	7.41	2
70	21	VG	100	85.19	100	14.81	3
70	7	AV	100	100	77.78	22.22	4
…	…	…	…	…	…	…	…
40	7	AV	40.74	100	77.78	81.48	19
50	21	AV	51.85	85.19	77.78	85.18	20
60	7	VP	74.07	100	37.04	88.89	21
40	14	AV	40.74	92.59	77.78	88.89	21
40	21	AV	40.74	85.19	77.78	96.29	22
…	…	…	…	…	…	…	…
40	21	VP	40.74	85.19	37.04	137.03	33
30	21	AV	0	85.19	77.78	137.03	33
30	7	VP	0	100	37.04	162.96	34
30	14	VP	0	92.59	37.04	170.37	35
30	21	VP	0	85.19	37.04	177.77	36

Having the ranks and the multi-issue distances determined, we provide the negotiator with the relevant cardinal data sufficient to decide which of any two packages (offers) is better and by how much. These scores may also be used to perform the symmetric analysis to determine the fair solution for both parties during the mediation or arbitration process or to visualize the negotiation progress and the concession paths [14].

5 Conclusions

The MARS approach proposed in this paper and derived from the fundamental notions of ZAPROS and MACBETH provides the negotiators with a straightforward tool that requires them to supply the basic preferential information only. As in ZAPROS, we are able to operate with an intuitively interpreted linguistic scale when defining preferences. If the negotiator is not sure of the strength of his preferences, he may simply declare that one offer is better or worse than another (without specifying by how much). The ZAPROS algorithm allows also to identify a small set of reference alternatives that need to be evaluated by the negotiator; these alternatives consist of the best resolution levels for all the negotiation issues but one (see sections 3 and 4). This makes the preference elicitation process easier and faster, since in a pairwise comparison of the offers the negotiators need to evaluate trade-offs only, which amounts to deciding which concession is better to make. This preference elicitation process based on trade-offs seems natural for negotiators since it is close to the actual decision making analysis encountered in a real-life negotiation, when comparing various offers from the subsequent negotiation rounds.

Then, by applying elements of MACBETH analysis we are able to determine the strong interval scale based on the verbal judgments defined by the negotiators at the beginning of the preference elicitation process. Using MACBETH allows us also to eliminate the major drawbacks of the classic ZAPROS; and thus (1) no two alternatives will be incomparable, and (2) potential inconsistencies in preferences can be easily tracked and eliminated from the preference elicitation process.

This way MARS eliminates not only the major disadvantages of VDA-based approaches but also the ones of the classic quantitative approaches (like SAW- or TOPSIS-based ones). It allows for verbal definition of the preferences over the potential trade-offs (negotiation concessions) releasing DMs from unintuitive assigning of abstract scoring points to options and issues, that may be meaningless or misinterpreted [17].

However, despite its simplicity the MARS approach may be tedious for the analysis of big negotiation problems. The number of the negotiation issues and options significantly influences the number of potential comparisons to be performed in the decision matrix. This problem may be partially solved by using the notion of predefined verbal categories limited in number for each negotiation issue (as recommended in the classic ZAPROS algorithm).

Another issue that requires further analysis is how the scoring system obtained by means of MARS for all the packages that can be built out of the salient options (i.e. identified in the negotiation template) may be extended to other potential packages. During the negotiation process a new offer may appear that consist of the options whose values lie between those of the salient options defined in the template (but that still fit the feasible negotiation space). The initial decision matrix cannot be arbitrarily enlarged, since this may result in a huge number of comparisons that the negotiator will not be willing to evaluate. In such a situation a TOPSIS approach may be applied, whose key parameters (such as weights, distance metric and data normalization procedures) will be estimated automatically to preserve the initial ranking and the rating of the reference alternatives. Such a TOPSIS-based scoring formula would allow to rate any feasible offer identified within the template.

We will study all the issues listed above in our future research.

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Simulating optimal negotiation strategy in risk management for networks with cascading failures

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Abstract. Important economic systems, like financial, transportation or electricity, can be represented as interconnected networks. Those networks often spread across many countries. Each country has its own regulatory institution with different objectives that can make independent decisions. Hence, each sub-network is being managed on a local scale. However results of those decisions can be observed on an international scale due to network's cascading failure property — a failure of a single node leads to an increased probability of failures in adjacent (connected) nodes. Hence, a decision made by one regulatory body can strongly affect the other involved parties. In order to ensure an optimal network operation the countries can coordinate the their regulatory policies using some negotiation protocol.
In the paper we formulate a problem of searching for an optimal negotiation strategy for a network risk management where decision makers negotiate a global decision regarding the network maintenance. The problem is tackled through a simulation model that allows to analyze possible outcomes of various offers placed by a negotiating parties.

Key words: multi-objective negotiation, negotiation process simulation, network risk management, cascading failure

1 Introduction

Several systems can be represented as networks including financial, transportation, liquid gas, electricity systems. The above networks have two common features 1) exhibit *cascading failure* property [1] i.e. failure of single node can result in malfunction of adjacent nodes and 2) are transnational i.e. expand across several countries.

The cascading failure property means that a malfunction of a single node leads to an increased probability of failures in adjacent (connected) nodes. Such situation can be observed for an example in financial markets when problems of a single company can result can result in problems for connected companies and can lead to crises on large scale [2]. Cascade failure has been shown to be an important factor shaping the recent financial crisis [3, 4]. Hence, a need for network optimization approaches arises that will lead to an increase of network robustness against failures [5]. However the transnational feature of large scale networks leads to heterogeneity in malfunction probability and means a distributed decision making process with several decision makers. An international network consists of several connected national networks with higher connectivity level within a single country than the connectivity on the entire network. The heterogeneity of malfunction probability means that different countries have different budgets and resources to keep a network at an operational state. Hence, the average node malfunction probability can vary substantially among countries. Each country has independent bodies that decide on its network maintenance. However, due to networks effects (e.g. cascading failures) decisions made by one country strongly depend on the malfunction probability in other countries. This can be observed in economic systems - for example the Iceland crisis resulted in run on connected banks in the UK and Netherlands. Moreover, the malfunction probability is heterogeneous throughout the network. Heterogeneity of malfunction probability means that different countries have different budgets and resources to keep a network at an operational state. Decisions made by one country strongly influence cascading failure probability in other countries due to networks effects.

In the paper we analyze efficiency of various negotiation strategies of network maintenance with a simulation approach [6]. We show how adding a mediator who helps parties to reach a global optimum leads to a more efficient outcome than independent network maintenance optimization. Hence, we compare two scenarios for a network maintenance: (1) independent bodies optimizing decisions in particular sub-networks versus (2) a cooperative decision making where parties agree on the negotiation protocol jointly negotiate a global decision.

The remainder of the paper is aligned as follows. In the section 2 we formulate a mathematical model for negotiation on shared network maintenance. In the section 3 we present a simulation model and simulation results. We conclude in the final remarks section.

2 Negotiating network maintenance in cascading failure setting

In the paper we apply the classical *multi-criteria decision modeling* (MCDM) approach for analysis of negotiation of an optimal network maintenance. Hence our description focuses on feasible decision made by negotiating parties and outcomes of those decisions.

Let's consider an undirected network (graph) $G = (V, E)$ having k nodes. The ordered pair (V, E) comprises of a set of nodes (vertices) V and a set of edges E, where each edge is represented as a pair of nodes (v, u), $v, u \in V$. A network G contains k nodes, i.e. $|V| = k$. Let $N(v) = \{u : (v, u) \in E\}$ be a set of neighbors of node v. We assume that G is undirected, i.e. $(v, u) \in E \Leftrightarrow (u, v) \in E$ and does not have self-loops, i.e. $(v, v) \notin E$. Additionally without loss of generality we will take that $V = \{1, 2, \ldots, k\}$. In this way each vertex can be simply referenced by its number. Business interpretation of the setup is that nodes of the graph are entities that produce value to their owners and edges indicate relationships between them. If edge between entities exists it means that failure of one node influences the risk of failure of the other node.

In the paper we consider $m > 1$ negotiating parties who negotiate decision regarding maintenance of the network $G = (V, E)$, where each party controls a part of the network. Each negotiating party i controls a subset of nodes $V_i \subset V$. Sets V_i cover whole set V and are disjoint. Formally we assume that $V_i \cap V_j = \emptyset$ for $i \neq j$ and $V_1 \cup, \ldots, \cup V_m = V$. Let $k_i = |V_i|$ be the number of nodes controlled by party i. Under the above assumptions we have $\sum_{i=1}^{m} k_i = k$. The economic interpretation is that nodes of the network G are spread among m regions, where each region has it's decision maker responsible for regulatory policy.

Let $\mathbf{s}(t) \in \{0,1\}^k$ be a vector representing node states in time $t \in \mathbb{Z}$. We assume that 1 represents a node malfunction (or bankruptcy in case of companies or financial institutions) and 0 means a normally operating node. In the beginning of a simulation $t = 0$ all nodes are operational so $\mathbf{s}(0) = \mathbf{0}$. Similarly $\mathbf{w} \in \mathbb{R}_+^k$ represents node size (importance) in the network (it is not indexed by time because we assume that it is constant in time). The i-th elements of vectors $\mathbf{w}$ and $\mathbf{s}(t)$ will be presented by w_i and $s_i(t)$ respectively.

Let $p(v, t)$ be the probability that functioning node v in time t breaks down in time $t + 1$. We assume that the probability a node malfunction depends on it's endogenous probability of failure and state of the neighbors in time t.

$$p(v, t) = f(\overline{p}_v, N(v), \mathbf{s}(t), \mathbf{w}, h(v), x_v) \tag{1}$$

where $\overline{p}_v$ represents endogenous probability of v malfunction, $h(v)$ represents support (number of repairs) received by the node from the system regulator. Hence, the probability of node failure depends on node's endogenous fragility and state and size of neighborhood nodes. We assume that the help received by a node decreases probability for future failure i.e. $\partial p / \partial h(v) < 0$. Finally x_v represnts regulatory effort for the node x, $x_v \in \{0, 1\}$, where $x_v = 0$ means no additional regulatory effort is present for the node v and $x_v = 1$ means that a regulatory effort was made.

Similarly when the node v in time t is broken down it is being repaired in period $t + 1 + t_r(v)$ where $t_r(v)$ is the repair time. In the simulation model presented in the next section we assume that $t_r(v)$ is a random value drawn from Poisson distribution with the mean $\lambda = 3$ i.e. $t_r(v) \sim \text{Poiss}(3)$. When a node is being repaired the network regulator incurs repair costs equal to the node size w_v. Additionally we assume that after the repair the probability $p(v, t)$ decreases — each additional repair decreases the probability of next malfunction by half.

The processes of breaking down and fixing of nodes constitute the dynamics of the system. Notice that in the long run system reaches a state where all nodes are repaired — due to fact that having node repaired decreases the probability of future failures (in the example simulation it is assumed that each malfunction decreases node failure probability by half).

Each negotiating party i can make investments or regulatory actions regarding nodes V_i it controls. The decision to repair a particular set of nodes will be presented as $\mathbf{x} = [x_1, \ldots, x_k] \in \{0,1\}^k$, 0 means that no regulatory action is taken and 1 means that a regulatory action is taken for a particular node and it's bankruptcy (malfunction) probability is reduced. Depending on a particular economic system such a decision could mean inducement of strict control or support for a particular financial institution or (in case of transportation network) a decision can be an effort to optimize flow at a particular node v.

The goal of the negotiating parties is to find such compromise that for a random malfunction process the expected cost of network repairs (w_v) during the simulation period will be the lowest. Negotiation parties are constrained by the number of available regulatory decisions, i.e. we assume that for party i that controls the sub-network V_i the following budget constraint holds:

$$\sum_{v \in V_i} x_v \quad <= b_i \tag{2}$$

where b_i is the arability of regulatory decisions.

The negotiating parties evaluate outcomes of their decisions — minimize the the costs of handling network failures. Different network control/maintenance decision lead to different volumes of node failures (e.g. bankruptcies) and hence to different cost incurred by decision makers. As it was stated earlier we have assumed that the public (budget) cost of node failures to the node size $\mathbf{w}$.

Since the nodes may fail with a given probability $p(v,t)$ the outcome of decision $\mathbf{x}$ is random and is changing from one simulation run to the other. Let $\psi_i(\mathbf{x})$ present expected outcome for a considered compromise x for decision maker i (taking into account all costs incurred by party i in the whole simulation process), which she wants to minimize. The value of $\psi(\mathbf{x})$ cannot be observed directly but has to be obtained as an can estimated through averaging repeated simulation of them model for given set of parameters $\mathbf{x}$.

The goal of the negotiation process is to find a network regulation that minimizes expected malfunctions costs for all parties. The negotiating parties sequentially propose regulatory policy $\mathbf{x}$. The outcomes $\psi(\mathbf{x})$ for a given policy $\mathbf{x}$ are calculated with the network simulation model. A sample network controlled by two parties has been presented on Figure 1.

3 Simulated negotiation outcomes for network with cascading failure

We use simulation analysis to analyze possible negotiation outcomes for network maintenance decisions we propose simulation analysis. The simulation model was created with the Python[1] [8] programming languages using NumPy [9] and the NetworkX library [10] — this is a standard approach for computational computing of network dynamics [9]. The description of simulated negotiation consists

[1] after creating the simulation model in Python we rewrote some of its parts in Cython [7] in order to increase the computational speed

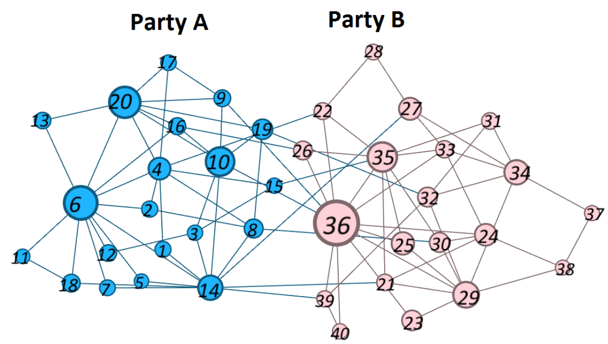

Fig. 1. A sample network structure controlled by two parties who jointly negotiate regulatory decision. The *Party A* could be particularly interested in the status of the node v_{36} since a malfunction of that particularly large node may spread to it's node.

of two parts: In the section 3.1 we discuss the simulation model and simulated negotiation scenario while in the section 3.2 results of simulation experiments are presented.

3.1 Simulation scenario

Two negotiation-simulation scenarios for negotiation simulation policy:

- *local optimization scenario* - the parties independently decide on regulatory policy for their share of the network — i.e. decision regarding nodes $v \in V_i$.
- *global optimization scenario* - the parties jointly negotiate a global regulatory policy $\mathbf{x}$.

In the *local optimization scenario* we assume that single decision maker i can influence only its own nodes, i.e. those elements of $\mathbf{x}$ that are indexed by values from the set V_i. We assume that parties $1, \ldots, m$ make their decisions sequentially. Without loss of generality we take that the sequence is given by decision maker number (starting from 1 and finishing with m). In the *global negotiation scenario* the parties negotiate regulatory scenarios $\mathbf{x}$, $\mathbf{x} \in \{0,1\}^k$ for the entire network.

We assume that the negotiation protocol agreed by the parties enforces that offers are placed sequentially by the negotiating parties. The expected value of each offer is evaluated with a simulation. Hence, the offer placed in step s will be represented as $\mathbf{x}_s$. Analogously for sequential individual decision making we will shall represent a decision of i-th decision-maker at step s by elements of $\mathbf{x}_t$ contained in set V_i.

We consider a simulated negotiation scenario with $m = 2$ parties with each decision maker controlling nodes $V_1, V_2 \in V$ respectively of a network G=(V,E). We assume that the network V contains $k = 30$ nodes with each subnetwork having 15 nodes i.e. $k_1 = k_2 = 15$, node sizes $\mathbf{w}$ are generated from log-normal

Algorithm 1 Simulation scenario for network maintenance decision $\mathbf{x}$

procedure EVALUATE($\mathbf{x}$,G) ▷ regulatory compromise $\mathbf{x}$ for the network G
  $t := 0$, $\mathbf{s}(t) := \mathbf{0}$
  $total^{(1)}_{CTR}, total^{(2)}_{CTR} := 0$ ▷ total costs for repairs of both parties
  Randomly select two nodes $v_1, v_2 \in V$
  $s_{v_1}(t) := 1$, $s_{v_2}(t) := 1$ ▷ simulate node failure
  repeat
    t:=$t+1$
    Calculate $p(v,t)$ for all nodes $v \in V$ ▷ failure probability
    for all $v \in V$ **do**
      if $p(v,t) > rand()$ and $s_v(t) = 0$ **then**
        $s_v(t) := 1$, $t_r(v) \sim \text{Poiss}(3) + t + 1$
      else if $s_v(t) = 1$ and $t = t_r(v)$ **then**
        $s_v(t) := 0$ ▷ Recover the node v
        $total^{(j)}_{CTR} \mathrel{+}= w_v$ ▷ update total repair cost for respective party j
      end if
    end for
  until $\mathbf{s}(t) = \mathbf{0}$ ▷ all nodes repaired
  return $(total^{(1)}_{CTR}, total^{(2)}_{CTR})$ ▷ a two element tuple is returned
end procedure

distribution $\mathbf{w} \sim LN(0,1)$. The network G, $G = (V,E)$ is generated as preferential attachment network [11] where node sizes are used as weights (attachment probability for a particular node v is proportional to w_v).

For a given network $G = (V,E)$ we simulate exchange of regulatory offers by the parties. For each offer $\mathbf{x}$ a outcomes $\psi_i(\mathbf{x})$ are estimated through simulation according to the Algorithm 1. Hence, a value of the stochastic function $evaluate(\mathbf{x}, G)$ needs to be calculated many times in order to achieve statistical significance. In order to reduce variance and ensure comparability of results we use the common random numbers technique [12].

3.2 Simulation results

We have simulated local optimization scenario for the negotiation presented in the previous subsection.

The simulations have been carried out for various networks $G = (V,E)$. Simulation trajectories in the local optimization setting for three network structures (G_a, G_b, G_c) have been presented on Figure 2. In order to enable comparison each regulatory scenario $\mathbf{x}$ can be identified on the figures by the scenario number. For each network structure G_a, G_b, G_c a global optimal decision has been identified, where the goal function was sum of the total network malfunction costs incurred by both negotiating parties.

We can observe three different negotiation process trajectories can lead to three types of inefficiencies:

1. *unstable cyclic exchange of offers* – In each step a party performs a local optimization and provides a regulatory scenario. The other party adapts it's

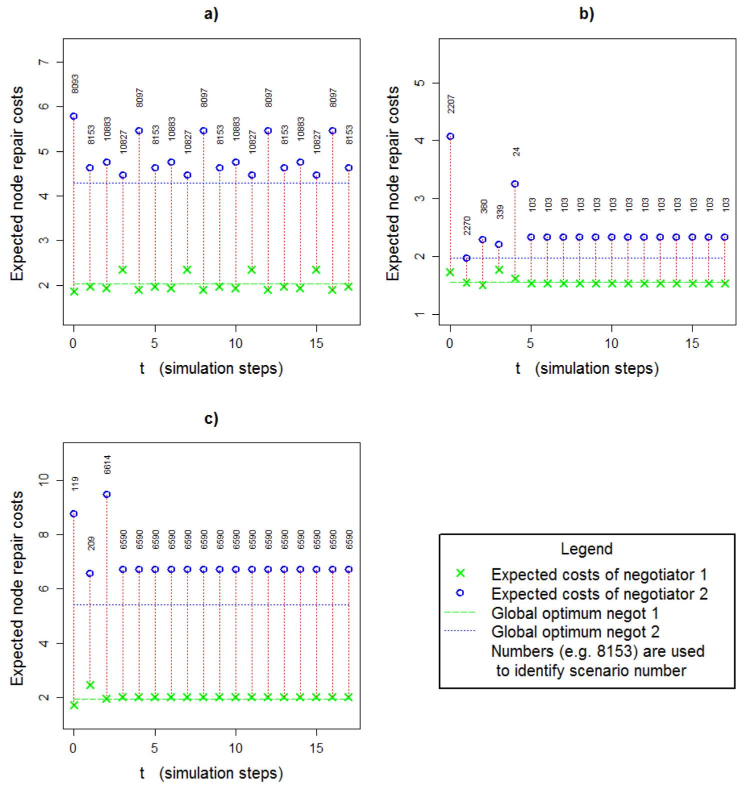

Fig. 2. Simulated negotiation dynamics for three random network structures G_a, G_b, G_c The negotiation process sequentially blocks non-Pareto efficient local optima. Parties should only consider a set of Pareto-efficient decision with different regulations.

regulation accordingly and in next turn the first party again changes the regulation (Figure 2-a).

2. *non Pareto-efficient equilibrium* – parties locally optimizing their offers end up with an equilibrium that is not Pareto-efficient and are unable leave that equilibrium with local optimization (Figure 2-b)
3. *Pareto efficient equilibrium that can be improved by cost transfer* – A small increase in costs for one party could lead to a substantial decrease of costs for all parties (Figure 2-c).
4. *Pareto efficient equilibrium that needs no further improvements* – for some simulated scenarios local optimization leads to global Pareto-efficient optimum without clear benefits from possible transfers.

The simulation results show that the local optimization scenario leads to non Pareto efficient compromises. Hence, a need to introduce a mediator arises that would help parties to search for a globally Pareto-efficient compromise.

4 Final remarks

In the paper we have applied the simulation approach to analyze outcomes of various negotiation processes for network system control.

The results show that agreeing the common maintenance scenario at the negotiation table can lead to more efficient outcomes than local decision optimization by particular decision makers without contacting other parties. However we have also shown that in some simulation scenarios where parties do not decide to negotiate a common network maintenance strategy but take decisions independently the achieved equilibrium can still be Pareto-efficient.

The further research will focus on extending simulations to multi-lateral negotiation scenarios and making the costs of regulatory decisions dependent on the node size. Another interesting area is calibrating the simulation model with data from some parts of real-world networks.

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Towards Individual Negotiation Training for Negotiation Support Systems

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Abstract. Negotiation support systems (NSSs) are complex systems that require dedicated training of end users in order to use these systems effectively. So far, trainings have not taken into account the individual characteristics of the negotiators. In particular, learning styles influence the way new knowledge is acquired in the best possible way. Therefore, two different end-user trainings for the NSS Negoisst are developed following either an enactive or a vicarious approach to negotiation training based on the individual learning style of the trainees. These trainings are evaluated conducting a negotiation experiment assessing learning outcomes.

Keywords: negotiation training, negotiation support systems, end-user training

1 Using End-User Training to improve the usage of Negotiation Support Systems

Since the late 1980s, more and more support functionalities have been integrated into negotiation support system (NSS) to provide a holistic support. Negotiators need to be familiar with these systems as well as understand their features to use them effectively. NSSs need to mature by taking the human characteristics of individual users and groups of users into account [1]. Consequently, human aspects of NSSs need to be addressed. End-user training (EUT) is a common tool used to introduce information systems (IS) in companies. EUTs have been found to increase utility and adoption of the IS in use effectively [2]. Negotiation training has its roots in management education and several studies show the willingness of negotiators to use NSSs for negotiation training [3, 4]. Nevertheless, such trainings do not take into account individual learning characteristics of the trainee. Rather, they follow the same teaching (and thus learning) approach for all participants. Therefore, the research task of this paper is to develop an end-user training for negotiation support systems using individual characteristics of trainees to increase NSS usage effectiveness and efficiency.

To fulfil this research task, the methodology of design-based research (DBR) is used [5, 6]. DBR focuses on the development, evaluation, and iterative improvement of learning interventions within real-life educational scenarios aiming to enhance design principles and derive new theories. Using a DBR approach thus enables us to develop an end-user training for NSSs and at the same time to construct a comprehensive picture of all social and technological variables involved.

2 Relevant Characteristics of End-User Training

Based on the research framework for EUT literature shown in figure 1, relevant characteristics of end-user trainings are defined [7, 8]. Most importantly, EUTs have to be adapted to the specific target system; in this case the NSS Negoisst [9, 10]. In the pre-training phase, training goals have to be defined, which relate to the learning outcomes to be measured afterwards. According to Bloom [11], these learning outcomes can be differentiated into skills, cognitive outcomes, affective outcomes and meta-cognitive outcomes. This definition of training goals is affected by the epistemological perspectives of the designer.

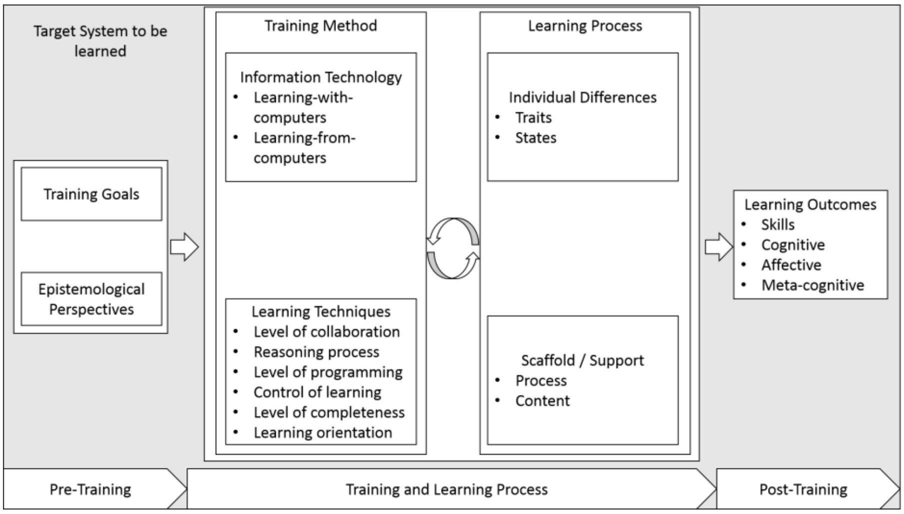

Figure 1 Framework for EUT research (adapted from [7, 8])

The main EUT contains the training method to be implemented, the learning process as well as their interaction with each other. Concerning the method of training, it should be specified whether to use computers as trainers or as a medium of training. Also the learning techniques need to be specified following the underlying training methods [12]. Gupta et al. [7] recommend observational learning techniques distinguishing enactive (i.e. observing one's own learning process while constructively acquiring new knowledge) and vicarious (i.e. observing and imitating experts to acquire new knowledge) learning. Proceeding to the learning process individual differences of trainees influence the EUT, which can be operationalised using learning styles [13]. The support of the trainees regarding content as well as process also has to be adjusted to their individual level of competence.

3 Best Practices in Negotiation Training

Whilst there are numerous articles on face-to-face negotiation training, literature on training of electronic negotiations is scarce. Until now, most of the negotiation training methods do not use technology at all and only few electronic negotiation trainings have been developed [14]. Similar to EUTs, electronic negotiation training has to transfer both negotiation knowledge and NSS knowledge [15].

Negotiation training typically follows the theory of experiential learning [16]. Experiential learning is rooted within the paradigm of constructivism describing an inductive cycle of learning (which is applied to negotiation training by Lewicki [17, p.257]: (1) exposure to a new experience (cases, role plays, "live negotiations") (2) reflection on this observation (debriefing, journals and papers) (3) formation of general theories (lectures, readings) (4) active experimentation (personal goal setting). Trainees do not have to start at step one, but it is of vital importance to complete the cycle to achieve proper learning outcomes. According to Loewenstein's and Thompson's taxonomy of negotiation training methods [18], typical negotiation learning techniques corresponding to the phases above are (1) observational learning (2) analogy learning (3) principle learning (4) trial and error learning and learning via feedback. The former two learning techniques match a rather vicarious training method whilst the latter matches an enactive training method [7]. This taxonomy emphasizes the relevance of observational learning including negotiation experts as well as the focus on constructively acquiring knowledge and performing practical negotiation tasks. Using these methods, negotiation training is known to create a high involvement with the trainees [15].

4 Developing an End-User Training for Negoisst

To fulfil the research task of this paper, two end-user trainings for the NSS Negoisst have been developed using learning styles as measures of individual characteristics i.e. persistent character traits in the research framework presented above. For a detailed explanation of how the trainings have been constructed and evaluated see [19]. Both trainings include basics on negotiation preparation and negotiation strategies as well as an introduction how to use Negoisst following either an enactive or vicarious learning techniques. The learning styles are assessed using the Learning Style Questionnaire (LSQ) by Honey & Mumford [20] developed specifically for experiential learning. Honey & Mumford assign a specific learning style to every phase of their adaption of the experiential learning cycle, which are especially good at the tasks necessary to accomplish this stage: (1) activists striving for new experiences, (2) reflectors reasoning on observations, (3) theorists generalising their findings and (4) pragmatists planning their next steps. It is assumed that the enactive training matches the preferences of pragmatists and activists, while the vicarious training matches reflectors and theorists. Focusing on the learning techniques, computers are only used as means to access Negoisst.

The enactive EUT is based on a negotiation case study including practical tasks for the trainees. After a brief introduction, the trainees have to acquire negotiation basics, prepare a negotiation, get familiar with Negoisst and use it to implement their prepared negotiation strategy in a training negotiation, following an inductive trial and error approach. The trainees are encouraged to explore the tasks in groups and later discuss their results in class. The trainer only moderates this discussion and reviews or supplements its results if necessary. Therefore, learning control is open to the trainees and a high level of interaction is supported. In the vicarious training, trainees are encouraged to learn individually from the trainer as a negotiation expert. The trainer, therefore, is asked to stay in front of the class and present the contents avoiding too much interaction. After a quick introduction the trainer presents negotiation preparation basics, strategies as well as the underlying concepts and features of Negoisst in a deductive manner. Then, the trainees are guided through the system by the trainer imitating a ready-made negotiation. Therefore, the vicarious training follows a programmed approach, keeping the learning control with the trainer.

5 Iterative experimental Evaluation & Preliminary Results

First, a pre-test involving 42 undergraduate management students was conducted to evaluate whether both trainings are distinct also verifying feasibility. Second, a larger negotiation experiment involving 178 students from two European universities was performed for empirical evaluation. Once learning styles were evaluated individually, an equal number of test persons of a specific learning style were allocated to each training, thus including matches and non-matches. Then an electronic negotiation experiment was conducted using a factorial design. Negotiation skills are operationalised measuring negotiation effectiveness as well as efficiency, while cognitive, affective and meta-affective learning outcomes are measured in a post-questionnaire.

The pre-tests manipulation checks showed that both trainings were constructed too similar, therefore they were modified as described above. The larger experiment showed a successful manipulation and significantly different EUTs. The assumption that a matching learning style and training method would lead to better learning outcomes, however, is only true for few variables. Therefore the relationship between learning styles and training methods will have to be evaluated in detail. Test persons attending the enactive training were more effective negotiators, especially benefitting from those among them with a matching practical learning style, which were particularly effective. Test persons attending the enactive training perceived higher affective learning outcomes, namely satisfaction with the negotiation [21]. These findings might be explained with the psychometric properties of individuals having a certain learning style. Practical learners are characterized as being flexible, open for change, but also insufficiently prepared and easily getting bored with consolidation tasks [20]. In terms of negotiations this could mean that they are easily proposing concessions in the beginning, but want to find a pragmatic agreement in the end without bargaining the details. An enactive training could lead to higher affective learning outcomes because its focus on practical, situated and collaborative tasks very much fits the requirements of negotiation trainings [17]. Regarding learning styles no effects could be seen here. In general, negotiation dyads of the same learning style achieved more efficient agreements than dyads with different learning styles. This effect has to be examined in the future. Until now learning styles have mainly been analysed as individual measures without focusing on their interrelations in dyads or groups.

6 Outlook

This paper describes the development of individual end-user trainings for the negotiation support system Negoisst using individual characteristics to increase learning outcomes as well as effective and efficient usage of NSSs. To develop the trainings, literature on end-user trainings, learning styles as well as negotiation training is integrated. The LSQ [20] is used to assess learning styles and develop matching end-user trainings following either an enactive or vicarious learning technique. These trainings are evaluated in two negotiation experiments, and the results show that there is no consistent effect of matching learning styles and training methods. However, enactive trainees are more effective negotiators also achieving higher affective learning outcomes.

In the future not only individual characteristics of the learners, but also their level of competence can be used to dynamically adjust their individual support. Also other measures of individual characteristics have to be evaluated besides learning styles. More domain specific measures such as the Subjective Value Orientation [22] might enable the construction of a broader picture of NSS end-user training. Our long-term goal is to automate individual end-user training for negotiations using blended learning or e-learning methods and dynamically select the individual form of training best for the trainee.

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A Pre-Negotiation Model for Water Resources Conflicts using a Value Creation Approach

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Abstract. The allocation of water resources has been a source of tension between people all over the world. The need for water which everyone holds in common should be a motive for cooperation and not conflict. Very often in a problem-solving conflict, the lack of information leads to a distributive negotiation. A distributive negotiation can turn into an integrative negotiation when values are created. We propose a model for pre-negotiation by value creation in water resource conflicts using Valued-Focused Thinking (VFT) approach. When values are created this means that the parties in conflict want a way to enhance the number of issues that will be shared between them so there can be improvements for all parties.

Keywords: integrative negotiation, value creation, water resources conflicts

1 Introduction

The fair allocation of water is a key issue in managing water resources and is regarded as one of the main reasons for conflicts related to watersheds around the world [1].

The need for management agencies to establish and adopt appropriate methodologies and policies for water allocation is recognized by researchers, government and experts in water planning. Despite this, there are still many obstacles to be overcome when seeking efficient, fair and sustainable allocations [2].

Negotiation has always been an important tool for resolving conflicts among people, countries and organizations. People cannot achieve all objectives by imposing their decisions; they must negotiate with each other as they depend on others to undertake their activities [3].

There are features regarding water resources negotiations that distinguish them from other negotiations such as among members of a supply chain, employers and employees. First, there are laws that regulate water resource management in each county that cannot be violated during the negotiation process. Also, decisions regarding water usually have a wider impact as they affect the population, social life, environment and economy of a region.

To improve and create new negotiation models, it is fundamental to analyze the relevant factors regarding the negotiation process for water resources, emphasizing the aspects that can contribute to designing tools based on the interests of the parties such that these facilitate understanding, communication and learning.

Identifying appropriate decisions makers (DMs), objectives, criteria and constraints on the problem should be done prior to the negotiation process and regarded as part of the phase of structuring a problem. This is a key element if the results of the negotiation itself are to be successful. Problem structuring methods can also be of great help when drafting Negotiation Support Systems (NSS) as a negotiation is a process of interaction and communication involving many variables. NSS tend to facilitate the negotiation process and make it more efficient; problem structuring helps the negotiator think outside the box and creatively define the problem, find new alternatives, objectives, and, in some cases, even decision opportunities.

Even in pure conflict scenarios, which often occur when allocating water resources, there could be coordination between the parties as in the well-known example of two sisters arguing over an orange, where one sister wants the whole orange to make juice and the other wants the peel to make marmalade. If they both have this information, each can have the entire part that interests them. Otherwise, they will compete for the largest piece of orange possible [4].

Water cannot continue as a source of tension between people living in the same geographical area; in fact, their common need should serve as a catalyst for cooperation, not conflict [5].

In an integrative negotiation other values are involved, enabling tradeoffs between the parties involved. A dealer might agree to invest in water pollution prevention if he can use a larger volume of water, while the population might agree to have access to less water if the smaller amount is of better quality.

Creation of value, exchange of relevant information, and problem structuring are key elements for integrative negotiation [6]. Thus, by engaging on these activities, awareness is raised of the importance of structuring problems involving water resources, before the negotiation process itself.

Strategic Options Development and Analysis (SODA) is a problem structuring method that helps the DM identify and learn about a problem. It uses cognitive maps and workshops as modeling devices to understand and incorporate individuals' views about the problem [7].

Another important method is Valued-Focused Thinking (VFT) by Keeney (1992). First, the DM focuses his/her thinking on values and only later on alternatives of how to achieve them. The method is structured to help compile a list of objectives and these objectives will later help the DM identify decision opportunities [8].

Based on that perspective, we propose a model for pre-negotiating water resource conflicts that sets out to help negotiators create values that make an integrative negotiation possible. The model uses VFT and SODA techniques to elicit objectives and structure them for each negotiator separately. The next step of the model is to aggregate the values elicited for all parties into a single list that represents the interests of them all. The facilitator enables this by holding a workshop with all parties involved in the negotiation process.

2 Proposed Approach

The objective of the proposed model is to assist negotiators to achieve a more cooperative environment by creating negotiation issues. The creation of values is possible by using problem structuring. The presence of a facilitator is needed to guide the whole process.

The first step of VFT will help DMs to think creatively about values individually. After creating a list of objectives, the VFT structuring step will separate them between mean objectives and fundamental objectives. Each negotiator will then have a list of objectives (issues) that he has an interest in negotiating.

The facilitator will aggregate the parties' lists of values into a single list. However, the parties will meet with the facilitator to agree on a single list that will contain all items that they are willing to negotiate. This meeting takes the form of a workshop, a step also used by SODA to aggregate cognitive maps. The structure of the method is summarized in Figure 1.

When a single list is defined for all sides, the negotiators will have a list with all the possible issues that might be considered during the negotiation. The negotiation process starts from there.

Note that alternatives are not being created; the main goal is to identify the different values of the interests of all negotiators that will enable them to think in cooperation with each other so as to achieve a joint gain by combining these values into alternatives while they are negotiating.

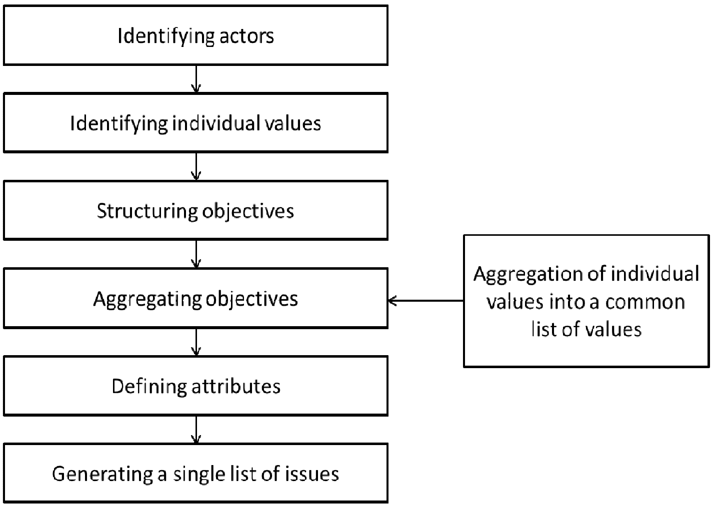

Fig. 1. Structure of the Model

2.1 Identifying Actors

This stage is used to identify all the actors involved in the process. The DMs are those whose objectives and preferences are elicited. They often have divergences regarding their value systems [9]. It has to made clear if they themselves will participate in the process or if they will contribute indirectly by having someone else represent them during the process (a client).

Other actors that might be part of the process should also be identified at this stage. In this model, the presence of a facilitator is mandatory.

2.2 Identifying Individual Values

In the first step VTF is used to identify objectives and structure these objectives.

The most obvious way to create value is to think in terms of the interests of the disputing parties - What do you want to achieve in this situation [10]?

Various techniques that stimulate the identification of objectives are shown in Keeney (1996) and include the questions below:

1. A wish list. What do you want? What do you value? What should you want?
2. Alternatives. What is a perfect alternative, a terrible alternative, a reasonable alternative? What is good or bad about each?
3. Problems and shortcomings, what is wrong or right with your organization? What needs fixing?
4. Consequences. What has occurred that was good or bad? What might occur that you care about?
5. Goals, constraints, and guidelines. What are your aspirations? What limitations are placed upon you?
6. Different perspectives. What would your competitor or your constituency be concerned about? At some time in the future, what would concern you?
7. Strategic objectives. What are your ultimate objectives? What are your values that are absolutely fundamental?
8. Generic objectives. What objectives do you have for your customers, your employees, your shareholders, yourself? What environmental, social, economic, or health and safety objectives are important?
9. Structuring objectives. Follow means-ends relationships: why is that objective important, how can you achieve it? Use specification: what do you mean by this objective?
10. Quantifying objectives. How would you measure achievement of this objective? Why is objective A three times as important as objective B?

Consider a dispute between the population and the agricultural industry in the context of water allocation; instead of only considering the volume of water that would be allocated to each party, they could also consider water pollution as another issue to be negotiated that could improve their current state.

A facilitator will help each side create an individual list of values that could be included in the negotiation process guided by the type of questions shown above.

2.3 Structuring Objectives

The first lists generated by the negotiators will include many items such as alternatives, constraints and criteria that are not objectives. The facilitator will guide the DMs as to how to transform these items into objectives and to classify them into means objectives and fundamental objectives [10].

Fundamental objectives concern the ends that DMs value in a specific decision context while means objectives are how they can achieve these ends. Notice that ends and means are context dependent [11].

This approach not only helps to identify all of the relevant objectives, including previously unrecognized objectives, but it also provides a logical and consistent way of identifying the relationships among objectives [11].

2.4 Aggregating Objectives

With the lists of objectives of each negotiator at hand, the facilitator will aggregate these values into a single list identifying clusters. Similar objectives are put together in the general list while objectives not held in common will be discussed with the negotiators to see if they will make the final list or will be discarded.

The workshop is a very important step of the procedure. Not only will it be useful to define the list of issues, but it can also generate a friendly environment for the parties as they will work together as a team with the same purpose: that of enhancing the quality of negotiation results.

In the workshop, the facilitator will discuss definitions with the negotiators, withdraw redundant objectives from the list, and with the synergy created by the discussion, may even include new objectives. They will exchange information and concepts, and agree and disagree on what values they are willing to negotiate.

2.5 Defining Attributes

After having the lists of values aggregated into a single list, the group will also decide what attributes will represent the objectives, so they can evaluate how an offer could satisfy these objectives.

At the end of this step the negotiators will have a list of issues that could be used during the negotiation process that would contribute to integrative negotiation. That does not mean that the parties would have to make use of all objectives to reach an agreement; they could find a compromise with just a few. If they find that is necessary or that they could achieve a higher joint gain by adding another issue to the negotiation that issue can be found on the list. In this case, preferences should be elicited again considering all objectives.

After the final list is available, the parties can begin the negotiation process itself.

3 Final comments

When value is created this means that the parties in conflict have found a way to enhance the number of issues that will be shared between them. Thus, there are improvements for all sides. The creation of values improves the chance of the parties getting what they want out of the negotiation in a more cooperative environment. This is especially important in the context of water resource conflicts as water has a vital role in the life and development of the population, which makes the disputes in general even more fraught and severe.

The model presented aims to create values to turn distributive negotiation into integrative negotiation so that the parties can rely on integrative negotiation models to reach an agreement.

The creation of values using problem structuring demands more flexible management of issues and options, so that new issues might be added to the negotiation process when should all parties agree to this. This would be possible by using an NSS that allows the inclusion of issues during the negotiation process in the existing model and considers the constraints and objectives already in the model and also the negotiators' preferences.

This study stems from on-going research and the next step will be to apply the model in a conflict about the allocation of water resources.

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What's Next? Predicting the Issue a Negotiator Would Choose to Concede On.

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Abstract. The aim of this paper is to propose a simple and intuitive model for predicting which issue an opponent would choose next for making concessions. The model is based on the concept of concession potential. The findings indicate that negotiators tend to rotate issues during negotiations, picking the ones with the most concession potential.

1 Introduction

Negotiations are an important type of exchange mechanism. Multi-issue negotiations allow the parties to look for the mutually acceptable agreements in an integrative fashion. This is due to the fact that parties may, in general, have different preferences over the issues. However, the preferences are kept private, thus making solution search an offer exchange process. Insights about the other parties preferences, as well as the ability to predict the opponent's moves may help the negotiator to better understand the opponent and plan offers accordingly.

Attempts to profile and predict the opponent have been reported in the past research. For example, past concessions made by the counterpart have been used to construct the model of the counterpart [1]. If, on the average, they exceeded a pre-defined threshold level, the opponent was modeled as having a "positive" attitude. Some other past works for profiling an opponent included: game-theoretic approach with Bayesian belief revision for modeling a negotiation counterpart [2]; probabilistic influence diagrams representing the counterpart's decision-making [3]; and opponent preference modeling using non-linear regression analysis [4, 5], Chebyshev's polynomials [6] and genetic algorithms [7]. There has also been work on predicting opponent's next offer using neural networks [8, 9]. However, neural networks are black box tools and one cannot, in general, get an insight into their workings. This work aims at providing a simple model for predicting on which issue a negotiator will make a concession next.

2 Concession potential model and next concession prediction

To formally define our concession potential model, we will require the issue (i) value (v_{io}) for an offer (o), the minimum ($\min(v_i)$) and maximum ($\max(v_i)$) value possible for an issue, thus permitting the calculation of the range ($r_i = \max(v_i) - \min(v_i)$) of potential concession for a given issue. We also have the total number of issues (I) and the total number of offers (O). The issues must always be converted to a range that that the highest value is the best possible outcome and the lowest is the worst possible outcome. Thus we can calculate the normalized remaining concession potential for an issue:

$$p_{io} = \frac{(v_{io} - min(v_i))}{r_i} \quad (1)$$

From the remaining concession potential, we can predict that the next concession that will be made will be for the issue with the least potential remaining, since this is the least preferred issue. Or we may predict the next offer to be made will be for the issue with the most remaining concession potential. For example, we have four issues, Price max=5 min=1, Delivery max=4 min=1, Payment max=3 min=1 and Returns max=3 min=1. If the last offer made was for a Price=4, Delivery=2, Payment=2, Returns=3 (see figure 1), then the next offer concession is predicted to be for Delivery if we assume that the negotiator will provide a concession on his least preferred issue. Or it may be Returns if the negotiator feels that the next concession should be on the issue for which there is the most remaining potential.

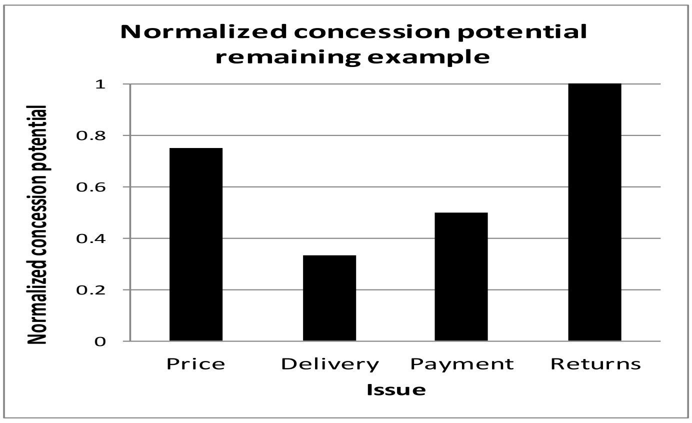

Fig. 1. Concession potentials

A more general model can be proposed with a memory parameter (m) which permits decay of the concessions over time. If the memory is set to zero, thus turned off, the model behaves as a naïve prediction model. If the memory is set to one, thus there is no decay, the model (3) behaves as the remaining concession potential model (1). Normalized and decayed recursive sum of concessions for an issue:

$$f(i,o) = \frac{\Delta v_{io}}{r_i \cdot I} + m \cdot f(i, o-1) \quad (2)$$

Normalized decayed remaining concession potential for an issue:

$$d_{io} = 1 - f(i,o) \quad (3)$$

3 Hypotheses

If negotiators are rational and rely strictly on a simple preference model for the various negotiations issues, a negotiator will continue giving concessions on the issue that is considered the least important.

H1: Negotiators will make concessions on the issue that is the least important to them, thus the issue for which they have given up the most concessions so far.

Alternatively, negotiators may have a more complex preference model, where subsequent concessions on the same issue are less desirable, thus meaning that the negotiator will make subsequent concession on different issues. Additionally, the negotiator may wish to provide concessions on alternate issues to probe for reactions from the counterpart and thus get a better understanding of the counterparts own preferences. In this case, the negotiator may choose to provide concessions on the issue that has the most concession potential remaining:

H2: Negotiators will make concessions on the issue for which there is the most remaining concession possible.

As a reference, we will also test the simple Naïve model:

H3: Negotiators will make a future concession on the same issue as that of their last concession.

It is also possible that negotiators change their preferences over time. In this case, the most recent concessions provide more information than older concessions. Since the normalized decayed remaining concession model (3) is more complex than the more simplified one (1) we would like to test to see if this additional complexity provides a benefit.

H4: The models with decay over time (3) will perform better than the model without decay (1).

4 Results

For testing the models a dataset from bicycle parts negotiation case was used: the same dataset as used in [8, 9]. Our findings are as follows.

H1: Not supported, p-value 0.00000. The empirical results demonstrate that only 21.1% of the time, the next concession made by the negotiator is for the least preferred issue, thus one with the most concessions so far. This is in contrast to a random issue which matches 33.6% of the time.

H2: Supported, p-value 0.00000. The empirical results demonstrate that 44.8% of the time, the next concession made by the negotiator is for the issue with the most remaining concession potential. This is in contrast to a random issue which matches 33.6% of the time. Thus we find that H2 is supported.

H3: Not supported, p-value 0.00000. The empirical results demonstrate that 20.2% of the time, the next concession made by the negotiator is for the issue same issue as the previous concession. This is in contrast to a random issue which matches 33.6% of the time. Thus we find that H3 is not supported.

H4: Not supported. For predicting the next concessions based on the least preferred issue, we find that with a memory parameter of 0.90, the model with decay (21.0%) performs almost identically to the model without decay (21.0%). For predicting the next concessions based on the issue with the most remaining concessions potential, we find that with a memory parameter of 0.90, the model with decay (45.5%) slightly outperforms the model without decay (44.8%).

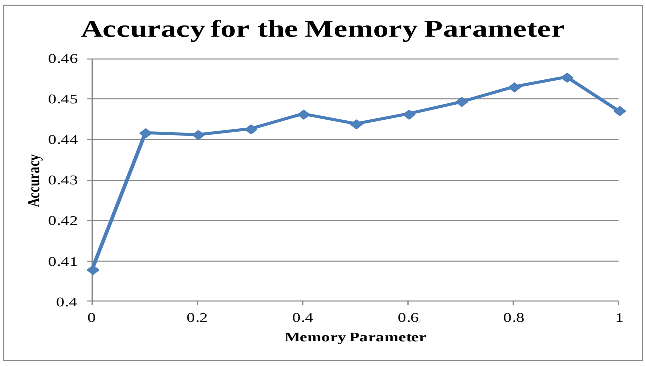

Fig. 2. Impact of memory parameter on prediction accuracy.

5 Conclusions

The current study has interesting findings into the nature of concession-making by negotiators. Apparently, they tend to rotate issues while making concessions. Also they tend to pick issues with most concession potential. Although we do not find a significant different between the performance of the models with decay and without, the model with decay is more general and more flexible since in can behave as the naïve model, the full memory model or anywhere in between, and thus might still be of interest in future research.

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Law by Design in ODR - definition of relevant legal information in consumer law disputes to enhance the decision making process

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Abstract. This contribution introduces a new theoretical completion to the online dispute resolution landscape and portrayals the performativity that a legal layer seems to convey to the lifecycle of a dispute, thus, to the decision-making process. We will substantiate the need to provide to consumers relevant and meaningful legal information regarding their consumer dispute. We envision with this perspective to go beyond the cartography of ODR and update the ODR and consumer law framework for a technologically-oriented environment and to the marketplace, by giving a new methodological trend, shaping the interface with the end-user and enhancing informed decisions.

Keywords: ODR, trust, legal information, consumer law, ontology, dispute resolution services, decision-making, mediation.

1 Introduction

The objective is to allocate into the Online Dispute Resolution[2] realm a knowledge-based system, that can endow meaningful and relevant legal information to the disputants (consumer and trader), concerning their consumer law dispute (the typical high-volume, low-cost value consumer disputes. In this instantiation, telecommunications and air transport passengers (typifies the industry with the higher rate of disputes and worst reputation, according to research [1], e.g. lost baggage, poor adsl connection, flight delay or cancelled flight, overbooking, amongst others. This approach might potentiate an early settlement and leverage consumers' trust, according to the European Consumer-Program 2014-2020[3].

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[2] Regulation n. º 524/2013 of the European Parliament and of the Council on online dispute resolution for consumer disputes (Regulation on consumer ODR), hereinafter termed simply as ODR. We consider ODR as a communicative process involving the parties engaged in an interactive decision-making task, as a mean for consumer redress.

[3] Proposal for a Regulation of the Parliament and of the Council on a consumer programme 2014-2020 (COM(2011) 707 final).

The innovation stands in the fact that in the current online conflict resolution space, even though the existence of technological innovation and maturity in the prominent players, there are no dispute resolution services (public nor private) nor methods (in negotiation and mediation[4]) that provides legal information on the content of the legal rule that applies to a conflict. The implementation of this legal layer into the technological and operational field, through an ontological modeling, may portray a completely new completion to ODR that is not negligible: a customizing knowledge-based support system, that applies and permeates the market - the *locus* where disputes occur. We intend with this vision to go beyond the cartography of ODR and update the ODR and consumer law framework for a technologically-oriented environment and to the marketplace, by giving a new methodological trend, shaping the interface with the end-user. To do so we will analyze in section 2 the current state-of-the-art of legislation and regulation pertaining to Online Dispute Resolution and we will point towards areas of regulation that are in need of adjustment or revision. In section 3 we intend to justify the need for the envisioned legal layer in reference to the disputants pre-conduct, having in mind the hyper law and hyper justice concepts that the average consumer contingently have and we assemble the advantages of such a legal layer to the stakeholders. In section 3 we figurate in general terms the legal cover into an ontology framework and in section 4 we conclude.

2 Brief literature review

In a brief overview, we evoke the prominent players and their techniques[5] and conclude that in the current online conflict resolution space there are no dispute resolution services (public nor private) that provides legal information on the content of the legal rule that applies to a conflict. Moreover, the EU Regulation primarily continues to rely on procedural rules (the coordination between the ADR entities)

[4] Mediation means a structured process, however named or referred to, whereby two or more parties, on a voluntary basis, try to reach an agreement on the settlement of their dispute with the assistance of a mediator. This process may be initiated by the parties or suggested or ordered by a court or prescribed by the law of a Member State, as stated in Article 3 (a) of the Directive 2008/52/EC, of the European Parliament and of the Council of 21 May 2008 on certain aspects of mediation in civil and commercial matters (OJ L136/3).

[5] Mediate.com that facilitates e- mediation and arbitration (www.mediate.com/); eBay's paypal dispute resolution system is settling 60 million complaints an year are processed through simple automated-negotiation (http://resolutioncenter.ebay.com); online chat rooms and document automation sites where disputants can meet up and exchange documents and evidence; VirtualCourtRoom, LegalZoom, RocketLawyer, HotDocs, Exari and Juripax are more elaborate mediator-sites with diagnostic forms, where conflict resolution is achieved by identifying and separating issues and collecting them in the same space; Smartsettle tries to find an optimal solution to conflicts based on preferences of the parties and even help shape negotiation strategies; Context-aware conflict resolution environments using ambient intelligence; Negotiating support systems (using algorithms such as Batnas and Watnas); SPLIT-UP, combination of rule-based systems and neural networks to assist disputes about properties distribution; FAMILY-WINNER, game theory-based approach for Australian family negotiations; BEST-project, semantic web technologies as support to law cases retrieval.

without approaching to the substantial content of the dispute, and both their theory and practice are saturated with the inferences of contact and communications theories paradigm[6]. Therefore, settling agreements "in the shadow of the law" [**Error! Bookmark not defined.**], or "in the shadow of procedure" should not be delegated to self-regulation, but within the law itself. It would reduce the need for participants in a consumer law dispute to divert excessive time and resources to schemes that are time-consuming, especially considering the inherent nature of consumer services and goods (telecommunications, gas, electricity, water, insurances, banking, etc.) Hereby we are cognizant that the inherent nature of the ODR concept is descriptively and theoretically incomplete. We argue that ODR has been developing without its own cogent theoretical base [3] which resides in providing legal information to the parties, promote access to justice and endow consumer protection (empowerment) and redress [4].

According to research, ODR experiences show some difficulties [5], such as lack of funding; lack of enforceability and the correlated reluctance to participate in ODR processes[6]; mediators might be seen biased and cannot give legal information to the case (absence of legal information is linked to the source of dispute). We emphasize the theoretical models of mediation techniques (for instance, pressing, facilitation, transformation, reflexive, evaluative, contextual, etc.) that are developed [7] and we even dare to quote this apprehension "(...) mediators have about 100 techniques at their disposal that are as varied as they are numerous (...) scholars have pursued three avenues, characterizing the behavior/techniques according to concurrent usage, technique similarity and similar goals (...)". Mediators are the "party control" of the communication process, the party that is parameterized in its role of healing relationships between the parties [8]. We concede that the mediators' and negotiator's role, regarding the strength and the content of the communication flow, would be more situated and intensified if the parties were in a previous stage endowed with the meaningful and relevant information regarding their domain of dispute.

3. The need for a legal layer

Consumer disputes have impacted interest and are often categorized by time-consumption, cost-disproportionality and are convoluted into complex procedures. It comprises acrimonious, since prolonged, legal wrangling which epitomizes long-term damage. Conversely, the presupposed characteristics can be avoided through technology that facilitates engagement with the relevant legal information in order to have customizability to consumers. Mediation in consumer law is particularly suitable to be modeled and integrated into a platform for web-based ODR semantic web

[6] According to the ODR Regulation 524/2013, we claim that is still a complex system (it is only the complaint that is submitted electronically and than it has a three-phase re-routing system not carried out online, but only through traditional ADR methods); time consuming, with a deadline from 3 up to 6 months; and it is still difficult to achieve to an agreement: if parties don't agree with the alternative dispute resolution body, or with the mediator, the process ends; also, if the dispute is not solved within the offers and counteroffers, there is a "time-out period" due to a dislogical performative structure workflow.

technologies [9]. As methodology, a legal ontology is a possible way to model the legal information layer and the disputes that could be incorporated by the ODR providers.

3.1 Pre-dispute conduct

We employ the *ex ante* perspective (looking forward from the point just before litigation has begun), back in the stylized chronology of the lifecycle of a dispute [11] to the point in time that precedes the conduct that gave rise to the dispute. From this perspective, we might consider that if the parties were knowledgeable about the applicable law and the abstract rights in their situation, there was no complaint and thus no dispute at all, or a dispute emerges with substantial cause (for further illustration, we conceive the plausible rights in the case of a delayed flight, or in case if there was no defect in the dress that was bought yesterday, but the color or the size was not aimed). In consumer law disputes, the stakeholders (ombudsman, regulators, ADR and ODR providers, consumer associations, among others) assume more palatably that the lack of legal information related to the case is linked to the root-cause of disputes [10]. We ascertain that if the current legal dispute resolution framework would encompass this "pre-dispute conduct", by assuring the layer of legal information (substantive rules), this would fulfill the desideratum of ODR: empowerment of consumers, readiness of consumers, their "smartening". We define, in this framework, the needed content and its participants: the primary conduct for disputes ("pre-dispute conduct", dispute acculturation or "self-litigation conduct") [11] is obtaining legal "relevant information", addressed to consumers, to ODR providers and to traders. Traders, which so far were considered economic entities, are being described as "information-based organizations", "learning organizations", "knowledge-creating companies" or "knowledge intensive organizations", within a knowledge information society that we live in. Providing relevant legal information as an early intervention, with settlement oriented style, is more likely to lead to high joint gains outcomes; thus, we will call this system as Law by Design in ODR.

3.2 The hyper law and hyper justice concepts

The missing link is the legal information for the case dispute. Legal information concerning the dispute domain (for instance, consumers, in general, think they have the right to cancel the contract when they have poor adsl connection; or when a flight is cancelled, consumers have a generalized idea that is due total refund), can be misunderstood with popular law [12] and popular understanding (polarization between popular law and expert law). Popular law consists in "popular right beliefs about ethical or legal issues disseminated in the media or network, wish is defined as "hyper-law""[13]. And the Web 2.0 and 3.0 have enhanced their scope and effects. And from hyperrealism, we will find "hyper justice" [13] due to the dynamic projection and unconsciously and subliminally consolidation of inner general concepts, values, principles, norms that ascribe nonexistent obligations and rights. This is what is known as "confirmation bias". Within a rights-based architecture of informational protection, by reconducting popular law into legal information can change this perspective.

We should not forget that in Online Dispute Resolution, consumers are "one-shooters" while businesses are "repeated players", dealing with a multitude of cases at any given time. Consumers will often get more involved in the dispute, taking it more personal, and thus requiring a more transformative solution, while the business is mostly interested in resolving the dispute as fast and inexpensively as possible [10, p. 151]. This features in consumer disputes sustain that ODR methods and techniques should be employed first and foremost to avoid consumer complaints in order to convey informed and clarified decisions and foster negotiation and mediation.

3.3 The average consumer

In the completion of the EU definition of consumer, the premise sets a single prototypical personification of an “average consumer"[14], which is the benchmark consumer known in the case-law[7] as the reasonably well-informed and reasonably observant and circumspect consumer, taking into account social, cultural, and linguistic factors, as interpreted by the ECJ. Nevertheless, the average consumer test overlooks the real world of individual consumer behavior and sets an overly demanding standard for consumers, though it responds to the appreciable intent of offering a useful tool to firms, their consultants, and the judicial authorities in the assessment of unfair commercial practices[14], dispute resolution (as negotiation and mediation) and ultimately, the decision making process. In fact, “consumers do not fall in a consistent unvarying category; choosing the identity of the benchmark consumer-as-victim is clearly of vital importance to the practical implications of a regime designed to control commercial practices which will not have a uniform impact on consumers precisely because consumers themselves do not form a homogenous group”[15]. For instance, this "average" definition doesn't comply with a consumer who is distracted or uninformed about the goods or services which are the subject matter of a commercial practice. Nor does it include those consumers who naively allow themselves to be convinced by deceptive exaggerations in advertising. Nor even doesn´t sympathizes with the "hyper justice" notion of consumers. The real consumer: the hypo-sufficient [16] consumer needs consumer protection through its legislation (the whole spectrum of enforcement of the different service directives) but also when facing dispute resolution. It is unfortunate that this salutary mechanism for promoting a fair and balanced decision between the transacting and disputant parties has been overlooked in the development of the conflict market, but we assert that law is still practiced as a reactive discipline.

3.4 Advantages for the stakeholders

The implementation of the legal layer into the technological and operational field, implies a new completion to ODR: a customizing legal-based system that applies and

[7] *Cfr. Sentence Gut Springenheide* (1998*)* C-210/96, 1998, C. I-:4567.

permeates the market - the *locus* where disputes arise. Feeding back legal domain information to ODR providers can be an asset in the conflict resolution market and will raise the legal standards of ODR. Information is central in our information society and it is important to find the right balance between information overload and too little information to make an informed decision. Information about the rights and the applicable law related to a claim is considered the "meaningful information" that consumers need. Thus, integrating a legal layer into the traditional workflow may endow the parties with the legal information that can, if the case, settle better afterwards in mediation, conciliation, arbitration. By allocating adequate information according to the case (legal information cover or legal validation regarding the policy of the companies), will promote access to justice and endow consumer protection and redress, it will replace the balance between consumers and the company.

In the consumers' perspective, an efficient delivery of self-tailored legal information service to end-users (by providing domain-specific information), may improve the awareness of consumers to personally evaluate the outcome of a potential litigation (self-litigation conduct), to be guided to a non-conflict settlement and to be assisted in selecting the potential support. It is foreseen to be a way to support the dispute and its resolution: consumers can determine their legal position (to go ahead with the claim or perceive that there is no case at all) at an early stage of dispute (which can discourage unmeritorious complaints). As such, we assume that consumers may feel entrusted (digital trust in e-society) and aware if the trader is acting in good-faith when filling a complaining and taking decision. Hence, we posit that this approach can avoid escalatory *versus* de-escalatory cycles if not solved in the earlier stage (and foster ulterior phases of mediation) and potentiates the continuation of relationship with the trader. Ultimately we can anticipate that providing the legal cover to the consumer as an early intervention[17] to the conflict, will provide earlier results on impacts on mediation; foster fewer impasses, produce more concessions leading to agreements (more willingness to compromise).

These essentials portray other estimable prospects: it may avoid overlapping jurisdictions between different ADR bodies (according to the EU Regulation of ODR) and the burden of proof from the rogue operator is mitigated.

In-House Customer Care or Internal Complaint Systems may incorporate this legal cover also in their mass customization strategy, and not only ODR providers. For the purpose of this paper we will only be concerned with the provision of the legal cover; undoubtedly, principles such as impartiality and independence are allocated, but we won't pursue these matters at this stage. It is a plausible deduction that such a legal incorporation may neutralize and calibrate the pronouncement offered by the internal business policies, which in turn, might improve the market behaviour and will maintain the legal compliance for every stakeholder. This leads us to the consideration that the envisioned legal information system can also reward the economic operators, such as reputable and competitive businesses that render consumer services and goods. As effective consumer policy, recharged with this legal cover, supports the proper functioning of the single market and drives out rogue operators, due to clear legal rules and better coordinated enforcement addressed by the companies. We assert that the market aims good practices to held the consumers allegiance, decrease the number of complaints (reputation and operational costs), which enables systemic accuracy. We contend that this configuration (customer centricity) can be seen as a quick response to the sectorial market problems which can incorporate preventive measures. The provision of ODR information by e-vendors can facilitate institutional based structural assurances, promote trust in e-vendors, and ultimately, advance (e-)commerce; business needs to conduct its business in compliance with regulatory guidelines (regulatory compliance).

4 Conclusions

In a prospective assertion, we aim to seek if this furnishing of one-to-one legal relevant information approach can become a one-to-many legal information decision-making tool, or Law by Design ODR. We are cognizant that the inherent nature of the ODR concept is descriptively and theoretically incomplete in order to attain an informed and clarified decision and we argue that ODR has been developing without its own cogent theoretical base which resides in providing legal information to the parties, promote access to justice and endow consumer protection (empowerment) and redress. The average consumer should have general but meaningful legal information about the rights that the law ascribes and therefore it would dimension is legal position at an early stage of a dispute (and avoid hyper law unreal conceptions). Any ODR provider or consumer business sector can evade from this transformation that will change the way to render consumer products and services and mechanisms relating to consumers. The use of industrial, commercial opportunities and service provision related to this evolutionary process represents one of the major challenges for every country's economy.

We acknowledge that in the present stage of research, it’s intricate to provide something more than simplistic and naive predictions regarding the inclusion of a legal layer into ODR, but only modest views for the revision of EU policies and regulations. The particular display of configuring the legal layer into ODR needs more empirical research to be fully understood. Models and tests are required to contrast or confirm the envisioned validity in a more general level, which is what we intend to present in the forthcoming research. Nevertheless, this new advent is a promising line of research for the future of ODR.

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PART III

Negotiation Support Systems

Negotiation Platform for Collaborative Networked Organizations using a Dynamic Multi-Criteria Decision Model

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Abstract. Globalization pushes companies to grow outside their political and geographical boundaries, frequently forcing them to increase product diversification and optimize their resource's management with potential and effective suppliers, for improving the relation with their customers. In this scenario, implementing agile collaboration networks between businesses is a requirement. In this paper we propose a platform to support the selection of businesses in the context of collaborative networked organizations, through a negotiation process based on a dynamic multi-criteria decision model (DMCDM). The platform combines DMCDM for evaluation and selection of suppliers and business partners with software agents, which autonomously capture business opportunities, select business partners/suppliers, as well as award and process associated orders.

Key words: Negotiation-based platform, collaborative networked organizations, dynamic multi-criteria decision model, software autonomous agents, heterogenous agents system.

1 Introduction

Establishing agile business partnerships is of utmost importance to companies in order to maximize business. By aggregating individual strengths and skills, while sharing risks and opportunities, companies may be able to improve their responsiveness to the market demands and react faster to their competitors.

Agile networks of companies, sharing common goals, require flexible tools, supporting their creation and operation. These networks may be founded as the result of strategic business decisions or as a dynamic reaction to a business opportunity detected by one or more of its members. A flexible platform is required to capture the opportunity, identify and select the best business partners and suppliers, assign partial orders and process their deliverables.

In this paper we propose a platform for supporting the evaluation and selection of businesses, in the context of collaborative networked organizations, based on a dynamic multi-criteria decision model (DMCDM) and software agents. The platform supports the dynamic selection of business partners and suppliers by combining a dynamic decision model, based on the works [1-4], with an information fusion method [5], to support partner evaluation and selection, integrating historical information, present status and forecasting about future information.

Following this introduction, this paper is organized as follows: In section 2 we provide a brief description of the proposed platform for supporting collaborative networked organizations. Next, in section 3 we refer to the businesses evaluation and selection, based on the negotiation process and an underlying multi-criteria dynamic decision model used. In section 4 we illustrate the proposed negotiation process through an example of use for the selection of businesses in the context of Collaborative Networked Organizations (CNOs). Finally, section 5 presents some main conclusions and future work.

2 Negotiation Platform for Collaborative Networked Organizations: an overview

CNOs may be defined as networks of largely autonomous organizations, geographically distributed and heterogeneous (in terms of their culture, social capital, goals and operating environment), which collaborate to better achieve common or compatible goals using computer networks to support their interactions [6], [7]. In CNOs there is an association of organizations adhering to a base long-term agreement and adoption of common infrastructures and operating principles [7]. Moreover, among CNOs there are usually temporal alliances between organizations that come together to share skills or core competencies and resources, in order to better respond to a collaboration opportunity. Those alliances dissolve whenever their goal has been achieved [6]. Networking and reconfiguration dynamics are the main characteristics of the CNOs, which aim at enabling and supporting business environments, assuring cost-effective integration in useful time and preventing the risk of leakage of private information about products or processes.

Figure 1 describes the proposed lifecycle for CNO and presents the detailed steps for the operation phase, which is the focus of this paper.

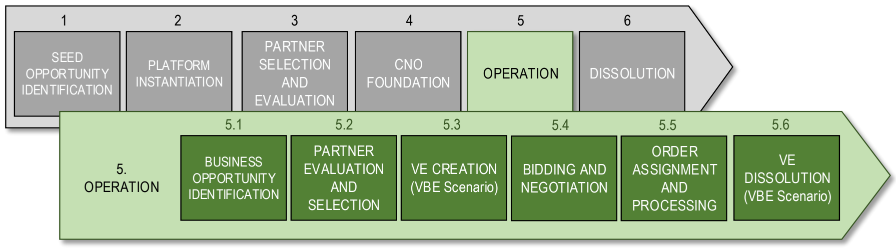

Figure 1. Platform Lifecycle.

Step 1 refers to the identification of one or more business opportunities. Next, the platform is instantiated, upon the action of one or more founder companies, via step 2. These companies may invite a set of well-known business partners or, alternatively, they may search and select their partners using the platform itself. Such partner selection phase happens in step 3. Once the platform is available including its partners, the CNO is created and configured in step 4. Next, operation starts in step 5. The sub-steps of the operation phase (depicted in Figure 1) are: once an opportunity is identified by a broker company (5.1) partners are selected to capture it (5.2). A new organization may be instantiated, if a broker company captures the opportunity and organizations are dynamically created as a response (5.3). This step is skipped in all other scenarios that do not include VE (Virtual Enterprise). Next, the supplier-business evaluation process is started (5.4). If an adequate quote is received, the order may be awarded to best rated business. Otherwise, a negotiation process may start (5.5). After the order processing has been fulfilled (5.6), the CNO may continue to operate or, alternatively, it may face dissolution as its last phase (steps 5.7 and then 6).

The proposed platform uses multiple types of software agents and as such it can be classified as a heterogeneous multi-agent system (MAS) [8], [9]. The agents considered are autonomous. The proposed MAS feature an agents' community, in which agents interact with other peers. While focusing on its individual goals, agents rely on other agents to solve parts of the problem, communicating and negotiating in order to improve the overall solution.

3 Underlying Businesses Evaluation and Selection Model

The proposed platform allows individual companies and members of an established CNO to select the best partners or suppliers, within a spatial-temporal changeable context. For this purpose, it will use a combination of a dynamic decision model [1-4], with an information fusion method [5]. Dynamic decision models appropriately cater for the impact of time within the decision making process. In [1] a dynamic perspective of the approach in [2-4] was taken to deploy a case-study, involving past, present and future information to achieve ranked list of partners and/or suppliers. A solid decision may then be taken based on the procurement management strategy the buyer company finds appropriate with its software agents modelling. Furthermore, since it is a spatial-temporal approach, it enables companies to change their strategic decisions periodically, without losing past information or acquired knowledge about future trends. Merging past with present information and forecasting for future trends may improve the quality of the decision making process, but it is not a risk free process. Moreover, imprecision [5] can arise from a variety of sources: incomplete knowledge, inexact language, ambiguous definitions, and measurement problems, among others. Models for supplier selection frequently lack support for dealing with imprecision, although assuming that precise data and preferences are available [1], [5], [9-11]. Fuzzy logic has been successfully used to help handle imprecision in decision making processes, particularly in Multiple Criteria Decision Making (MCDM) models [12-14].

4 Negotiation Process: Example of Use

The negotiation process of the proposed platform is triggered when: (1) one of the member companies needs to consume goods or services from one or more of its partners, to fulfil an order issued by a customer or another member; (2) a broker company captures a business opportunity and selects the companies that will process it. In both cases a Request for a Quote (RFQ) is issued using the platform, by activating an Order Agent (OA). This software agent assumes the "buyer" role. Figures 2 and 3 illustrate the supported negotiation process represented as UML sequence diagram [15].

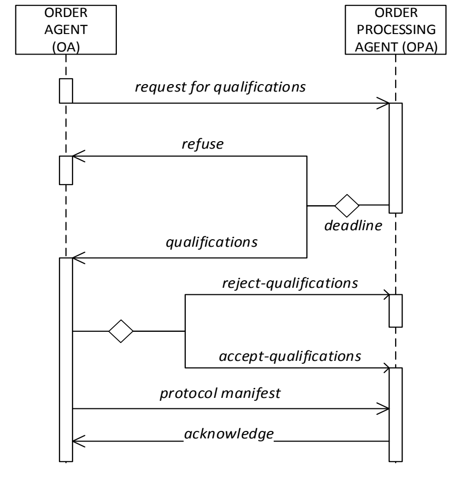

Figure 2. Negotiation process: request for qualifications.

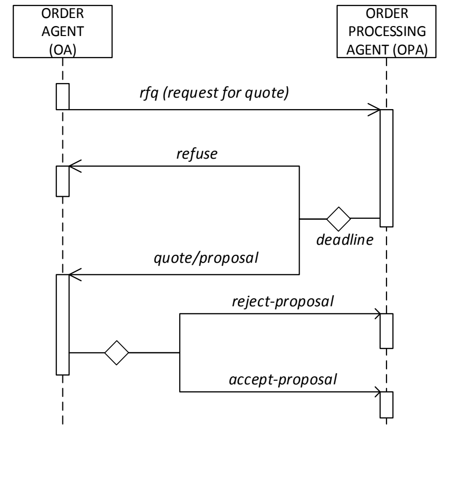

Figure 3. Negotiation process: request for quote and bidding

Initially the OA submits a request for qualifications. Its goal is to allow determining which of the business partners may be able to fulfil the associated request. Suppliers interested in the potential request will answer with their qualifications. The request for qualifications may include the need to comply with certain regulations, or standards, associated with the business. Additionally, it may demand potential suppliers to have specific certifications. An Order Processing Agent (OPA) issues the answer to a Request for Qualifications (RFQ), which is instantiated to represent the supplier in the negotiation processes.
The OA analyses the answers it receives and excludes any suppliers who do not comply with the minimum set of requirements. After that, eligible suppliers are integrated in a protocol definition phase. The OA publishes a manifest, enumerating the data it wants to exchange and its underlining structure. The OPAs representing suppliers interested in the business opportunity must acknowledge the acceptance of the protocol.

Next, the OA submits to the OPAs the RFQ, according to the agreed protocol, stating which values it wants to receive (for example, price, delivery time and lead time). Additionally, the OA may highlight the evaluation criteria it will use, if appropriate. After receiving an RFQ, each of the OPAs start a budgeting process. They calculate the price and may also interact with planning agents, associated with their company, in order to obtain the delivery and lead times it can propose, according to the current production schedule. Additionally, the Planning Agent may report the production capacity during the product, if that parameter is part of the negotiation protocol. The OPA will issue the proposal to the OA, according to the defined protocol.

The OA that submitted the initial RFQ will evaluate all proposals and quotes it received, comparing the criteria satisfaction, established for the evaluation. It may include criteria associated with the proposal (e.g. price, delivery time, lead time) and criteria associated with the supplier performance (e.g. On Time Delivery Performance, Defect Free delivery, Delivery delay mitigation, Defect Mitigation).

The evaluation will use historical information, information contained in the received quotes and also prediction of future values as described in the next section.

If none of the proposals or quotes is acceptable according to defined criteria, the OA may initiate a negotiation process with the top ranked OPAs. This process may start with an adjustment applied to some of the terms associated with the initial request, or as a completely new RFP. This option allows a company to divide an order in different parts if none of the proposals it received for the whole order was acceptable according to evaluation criteria. This segmentation, when possible, may generate finer grain RFQs, which trigger a new enquiry, and allowing different suppliers to be selected for different parts of the order's deliverables. The contacted OPAs will then build a new proposal or quote, if that is considered acceptable on their side. This new proposal is returned to the OA for a new evaluation.

At this stage an OA may find itself in one of the following situations: (1) it has a proposal at the top of the ranking list, and the order may be assigned to the top ranked company; (2) it has a set of proposals with similar ratings at the top of the list, making the OA apply individual selection criteria in order to define the best supplier; (3) the OA has no acceptable proposal or the best supplier cannot be determined, in which case the OA may divide the order in smaller segments, which in turn will generate new RFPs.

If the OA deems that one proposal is acceptable, it may go forward and proceed to the order phase (ending the negotiation phase). In this case, it sends a formal order to the OPA on the supplier side. In reply, the OPA sends the proposed plan for the order delivery. Once the order has been issued, monitoring its execution is performed by a Production Management agent (PMA), in the buying company, and by a Production Agent (PA), in the supplier, as illustrated in Figure 4.

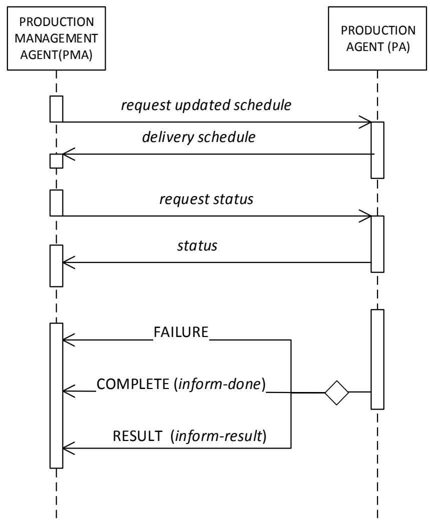

Figure 4. Order processing (represented as UML sequence diagram).

Periodically and according to the Schedule, the PMA agent will contact the PA agent to requesting an updated production status. As soon as the work is completed, the PA agent notifies the PMA agent that delivery will occur. When that happens, the PMA analyses the deliverables, and stores in a shared repository (1) the defect rate it detected and (2) the schedule fulfilment rate. After the PMA confirmed that the deliveries fulfil the requirements presented in the purchasing order, it ends its association with the process. The same happens with the PA on the supplier side. Both can now be assigned to process future orders.

4.1 Data preparation

For accomplishing the negotiation process, the OA needs to define the set of criteria to evaluate and rate each alternative with the aim to select the best business partners for a given business scenario. Alternatively, the OA may just want to evaluate the quotes/proposals it received as a reply to a RFQ/RFP. Examples of current criteria to evaluate proposals sent from different suppliers are price, delivery time, lead time, among others. For historical information, one may use defect free delivery rate, on time delivery performance and other criteria.

Historical information is gathered by the Production Management Agent (PMA), while interacting with Production Agents (PA). Historical information regarding the supplier's performance is gathered in the past matrix. Past criteria satisfaction values may be obtained from information stored in a database by PMA agents, which may belong to the buyer, or even the CNO to which both buyer and sellers belong. When analysing information about the past, parameters such as delivery time and lead time may not be important, as the company may be using historical information about previous orders with different constraints. In this case, price, on time delivery performance and defect delivery rates will be more useful.

When evaluating the present status, data included in the received quotes or proposals are of utmost importance. This may include price, lead and delivery times, and other specific data. This information may be aggregated with quality and delivery performance rates, thus allowing taking risk into account within the decision making process.

Finally, to build the future evaluation matrix, some kind of forecasting must be defined. In this case, since the PMA will autonomously issue updates about delivery estimates, they are responsible for defining the future matrix. The forecast may target criterion such as performance indexes and prices, basing the assumptions about future values on past performance patterns. Figure 5 illustrates the resulting vectors (ratings) for the past, present and future performance decision.

After obtaining the input values for all criteria, for the three matrices, all these values must be normalized before any fusion process can occur [5]. Normalization is essential to guarantee that values are numerical and comparable to enable being aggregated. In this work we propose to use a fuzzification process to normalize the data, based on triangular membership functions to represent the acceptable criterion values [14], where the functions represent attributes/criteria with "lower is better" and "higher is better". For example, criteria "price" will use as its normalizing linguistic term, "lower is better" because it is rather appropriate. The membership functions may be adjusted for each criterion, also considering the past, present or future evaluation processes. After the fuzzification process, we will have three updated matrices, where the cell's values (Figure 5) are substituted by the respective membership value, μ(x) and their aggregated value the resulting vector.

4.2 Criteria fusion & alternatives rating

At this stage, the order agent (OA) has three matrices with their respective cells values, (fu_{ij}) for each existing criterion, per alternative supplier, for the three temporal periods (past, present and future). Since we may have different criteria for each stage, the agent needs to aggregate them to obtain the resulting vectors for past, present and future scores, per supplier. It will use the aggregation method proposed in [5], as follows:

$$r_i = sum(\frac{L(fu_{ij})}{\sum_{k=1}^{n} L(fu_{ij})} * fu_{ij}) \tag{1}$$

where *fuij* is the filtered value for criteria *j* and supplier *i*, and *L(fuij)* is the corresponding weighted value.

After having fused the values associated with each criterion for the three types of matrices (past, present and future), the OA is now able to use the dynamic spatial-temporal process [1, 4] for obtaining the final rating for suppliers. Figure 5, illustrates the 3 time periods rating vectors (i.e. obtained by the fusion process done with equation (1)) and the final aggregated vector.

Past:	Present:	Future:	Final Decision:
$\begin{array}{c} Past\ rate \\ \begin{array}{c} S_1 \\ S_2 \\ S_3 \\ \dots \\ S_i \end{array} \begin{bmatrix} p_1 \\ p_2 \\ p_2 \\ \cdots \\ p_i \end{bmatrix} \end{array}$	$\begin{array}{c} P - rate \\ \begin{array}{c} S_1 \\ S_2 \\ S_3 \\ \dots \\ S_i \end{array} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ \cdots \\ a_i \end{bmatrix} \end{array}$	$\begin{array}{c} F - rate \\ \begin{array}{c} S_1 \\ S_2 \\ S_3 \\ \dots \\ S_i \end{array} \begin{bmatrix} f_1 \\ f_2 \\ f_3 \\ \cdots \\ f_i \end{bmatrix} \end{array}$	$\begin{array}{c} Decision \\ \begin{array}{c} S_1 \\ S_2 \\ S_3 \\ \dots \\ S_i \end{array} \begin{bmatrix} p_1 \otimes a_1 \otimes f_1 \\ p_2 \otimes a_2 \otimes f_2 \\ p_3 \otimes a_3 \otimes f_3 \\ \cdots \\ p_i \otimes a_i \otimes f_i \end{bmatrix} \end{array}$

Figure 5. Past, present, future rating and aggregated vector (fusion).

In Figure 5, $\otimes$ represents an aggregation operator such as the weighted average or any other operator. For example, if we use a weighted average we can consider that past information is more relevant than future one and assign more weight to this temporal-criterion than to the future one. Again, any other operator from geometric mean, parametric operators could be used for determining the final evaluation for each supplier.

In summary, the vectors are combined and the result is a decision vector with a single score per supplier, which after sorting will provide the ranking of all suppliers. The resulting vector provides more consolidated information for the buyer to select the best suppliers or business partners, since it reflects the supplier´s past, current and future expected behaviours. Obviously, the final ratings are greatly influenced by the chosen criteria, the defined weights and confidence and accuracy values considered. The buyer company may adjust these parameters, according to the customized specifications of its business scenario.

After obtaining a score per each possible supplier or business partner, the Order Agent (OA) may now assign the order to an Order Processing Agent (OPA), which, in turn, will return an updated delivery plan. The PM agent, to monitor production status and delivery performance, will then use the delivery plan. If the OA has a set of suppliers with similar ratings at the top of the list, it may apply additional individual selection criteria in order to define the best one, using an ordered list. Criterion such as Number of Previous Orders, Strategic Supplier Rating and others may be used. This ordered list is customizable and may be fined tuned according to the business scenario. Alternatively, the OA may start a negotiation process, in order to obtain better values in specific key criterion, since it already has multiple alternative proposals available.

Finally, if the OA has no acceptable proposal, it may divide the order in smaller segments, which in turn will generate new RFQs. For example, if no acceptable proposals were received for the development services needed for an Interactive application, including its design, the OA may divide the order in two different segments (development and design), each having potentially different delivery requirements, starting a new RFQ with the same companies or others. It may also include other companies, which were excluded during a previous phase, due to the incapacity of full filling the whole order (for example, a design agency which doesn't possess any internal development competences).

5 Conclusions

In this paper we proposed a negotiation-based platform for supporting the evaluation and selection of businesses, in the context of collaborative networked organizations. A dynamic multi-criteria model [1-5] that supports multiple business scenarios was used, involving heterogeneous companies that wish to reach new customers and access new markets through partnerships. The proposed negotiation process is performed with specialized software agents that cooperate to achieve their individual goals. Additionally, by using focused agents that assume targeted and well defined roles, the platform's evolution potential can be increased, as well as its flexibility and adaptation capacity in relation to evolving business scenarios.

Having Order agents, Project Management Agents and Production Management Agents to support the dynamic supplier and business partner evaluation and selection, based on supplied quotes, historical information and forecasting, enables the platform to reconfigure itself, in relation to its member's performance, capabilities and evolution. Furthermore, by supporting the full cycle of order processing, from bidding to delivery, the platform adjusts itself to internal operation dynamics. Finally, by using standardized messages for communication, and by providing interface agents focused on system integration, the platform allows participating business to integrate the collaboration network with their back-end systems, thus contributing for greater business agility.

A prototype of the platform is currently being tested on simulated scenarios, to evaluate its effectiveness. As future work, the authors plan to implement real cases of the proposed approach, establishing the complete platform lifecycle within a Virtual Breeding Environment of Virtual Enterprises that share the goal of increasing profitability and customers' satisfaction through constructive partnerships. One of the planned real cases is in the tourism market.

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Robust Discovery of Coordinated Patterns in a multi-Actor Business Process

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Abstract. In this work we propose a methodology based on the process mining approach to discover coordinated patterns of behavior in a customer service request handling process. We analyze a real dataset containing events from an incident and a problem management information system, and deliver results that eventually can raise the capacity of the company to manage the process. The core of the work comprises the looking for coordinated patterns among involved actors, a discrepancy analysis and a robust classification technique.

1 Introduction

Customer service request handling is a reactive business process that is triggered when a customer submits a service request to the help desk of a company. It has been identified as a core function of modern organizations, due to its tight relationship with their marketing function [1]. Establishing a service response capability includes a number of actions [2], like creating a service response policy, setting guidelines for communicating with outside parties regarding customer requests, selecting a team structure and staffing model, establishing relationships between the help desk team and other groups, both internal (e.g., technical support teams) and external, determining what services the incident response team should provide and staffing and training the incident response team.

There are multiple factors that affect the complexity of the process, such as the number of support teams involved, the organizational hierarchy, the number of products / product categories being served, special business rules etc. Due to the complexity of this process, special IT systems are often employed. A common practice reference model that introduces standard best practices for IT service management is the Information Technology Infrastructure Library [3]. Nevertheless, the processes described in ITIL are deliberately non-prescriptive. In practice, the actual behavior can significantly vary, not just according to the organizational implementation but because of a plethora of other implementation parameters as well (e.g. the resource performing the activities). Process mining

[4] is a promising approach to expose the real behavior of the process from IT systems' logs.

The process mining approach has recently attracted researchers for the service request management process analysis [5]. Since the respective process takes place in a highly flexible environment, multiple techniques are typically combined to deliver a solution. In [6], authors propose a combination of trace clustering and text mining to enhance process discovery techniques with the purpose of retrieving more useful insights from process data, while in [7] process mining is used to assess whether a business process is implemented according to ITIL guidelines. In this work we propose a methodology based on the process mining approach to discover coordinated patterns of behavior in a customer service request handling process. The process perspective is a necessary dimension of the proposed methodology, since ordinary data mining techniques would fail to capture the sequencing of the related events. Eventually, the results of this methodology can be used to raise the capability of the company to handle service requests by *i)* establishing more robust response policies and procedures and *ii)* aid the teams' structure decision, including outsourcing considerations. The basic steps of the proposed methodology is to arrange data with a process perspective (yet over multiple views), to draw the pertinent social networks, to perform a discrepancy analysis for the observed behavioral variation, and to apply a robust classification technique to explain the factors affecting the behavior and to deliver a predictive model for undesired behaviors as well.

2 Case Study

2.1 Description of the Case and the Dataset

Volvo IT Belgium provided a dataset[3] from its information system that supports the incidents management for the 2013 edition of the BPI challenge. The dataset contains events from an incident and a problem management information system. The primary goal of the incident management process is restoring a customer's normal service operation as quickly as possible when incidents arise ensuring that the best possible levels of service quality and availability are maintained. The dataset contains 65533 timestamped events related to the incident management process. Each record contains a number of variables such as the unique ticket number of the service request, the impact of the case (a measure of the business criticality of the incident), the case status (queued, accepted, completed or closed) and sub-status (assigned, awaiting assignment, cancelled, closed, in progress, wait or unmatched), the business area of the user reporting the incident, the technology-wise division of the organization, the support team that will try to respond to the service request and the location that takes the ownership of the support team.

The process is roughly the following: A customer submits a service request. The process reactively triggers a "first line" response, in other words, the Service

[3] doi:10.4121/500573e6-accc-4b0c-9576-aa5468b10cee

Desk or the Expert Help Desk tries to resolve the issue. When this is not possible, the case should be escalated to Second Line and/or Third Line teams. The quick resolution of the issue is defined within Service Level Agreement of the company.

2.2 Description of Patterns

There is an announced policy of the company that most of the incidents need to be resolved by the first line support teams (mainly service desks). This is called “Push to Front” tactic and it is mostly a matter of efficiency. Pushing to Front, allows the 2nd and 3rd line support teams to focus on their special, more demanding tasks (usually not related to customer service support). Unless this tactic is consistently applied a lot of ’easy’, big volume cases will end up in those lines. The definition of push to front in this paper refers to the case when the 1st line support teams can resolve the service request without interference of a 2nd or 3rd line support team. As such, pushing to front is an important coordinated pattern that may arise during the process execution.

Besides pushing work towards the front, any team upon receiving a task can either try to resolve the issue by itself or hand over the task to another team (of the same or of another line). Handover of work is an ordinary action, however if this is excessively used it may have an inadmissible effect on process efficiency. Namely, extensive handover may reveal dodging or deferring behavior. The opposite (extensive takeover) may also reveal some undesired elements like lack of collaboration mentality of lack of knowledge transferring. Therefore, the inter-team handovers may also include coordinated patterns of (social) behavior.

A special case of handover of work is when support teams send the same case to each other again and again. We shall call this undesirable situation “Ping Pong”. The definition of “Ping Pong” that we use in this work is that a Ping Pong occurs when a support team is revisited during the case, after it has passed the work to another team. However, we count a single Ping Pong per support team, even if this is revisited multiple times. This definition allows for a numeric representation of the Ping Pong behavior (a case may have multiple Ping Pongs, yet attributed to different teams). Ping Pong is also an undesirable coordinated behavior that may affect significantly the process performance.

3 Looking for Patterns

The dataset in its original format contains a list of timestamped events. It is quite hard to elicit patterns of behavior from within this format, since the sequencing of events and their aggregation per case are not exploited. Therefore, the leading step is to reach a process perspective for the dataset. In particular, the methodology unfolds in the following stages:

1. Commit data to process format
   (a) Control flow-wise (trajectories of status / substatus changes)
   (b) Social-wise (transactions among support teams or lines)

2. Discover the process map and check the flows.
3. Get the social networks for the social-wise process view and analyze social behavioral patterns
4. Perform a discrepancy analysis to analyze how the state sequences are related to one or more covariates
5. Apply a robust classification technique for both explanatory and predictive purposes.

3.1 Control Flow-wise Patterns

Control flow refers to how the status / substatus of a case changes during its lifecycle. There are 13 distinct alternatives for the status / substatus of a case (presented in Table 1). Although the set of activities (status changes) is small, we noticed that there are 2278 different variants of the same process (for a dataset of 7554 cases). Out these 2278 variants, just 88 have a frequency higher than 100, while the dominant variant represents just a 23% of total cases, a fact that confirms that the process environment is highly flexible.

Since there is no strict sequencing rule, discovering an exact behavior would not reflect the real situation, and would probably be of little importance. In general terms, cases go from some *Accepted* substatus to either a *Completed* substatus or to *Queued*. In the latter option, the case returns to an *Accepted* substatus. A process map is depicted in Fig. 1, where some labels for performance measures are printed. In particular, the heavier the weight of an edge, the worst its performance. The illustration has been created using Disco® [8] and it is a direct way to visualize the process' bottlenecks. The largest delays happen between Completed-Resolve and Completed-Closed (7.2 days), Accepted-Wait User and Completed-Resolve (5.3 days) and Accepted-Wait Implementation and Completed-Resolved (4.7 days). It is also interesting to regard that there is a meantime of 4.3 days between the Completed-Closed status and the Accepted-In Progress status, a fact that indicates that some cases are closed only to be re-inititiated after 4-5 days.

Status	Substatus
Accepted	Assigned, In Progress, Wait, Wait-User, Wait-Customer, Wait-Implementation, Wait Vendor
Queued	Awaiting Assignment
Completed	In Call, Resolved, Closed, Cancelled
Unmatched	Unmatched

Table 1: Status and Substatus alternatives

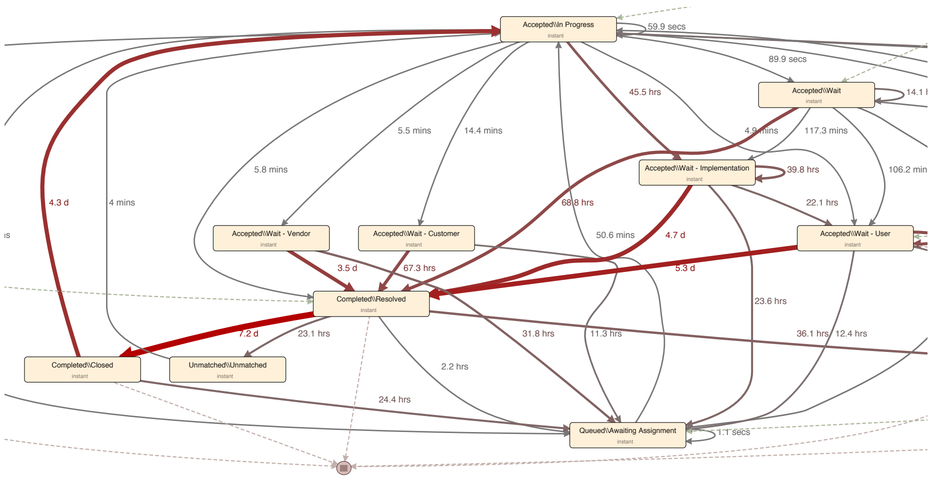


Fig. 1: Process Performance Map

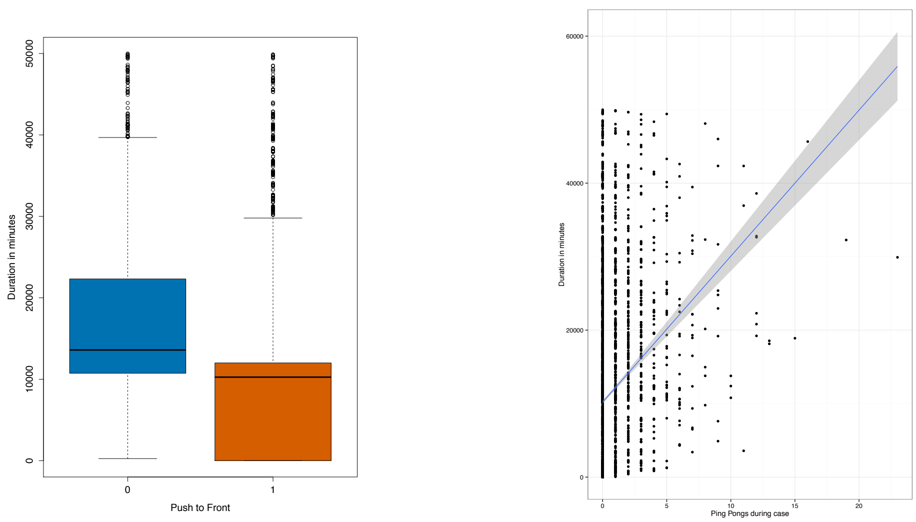
3.2 Social-wise Patterns

First of all, we need to evaluate the "Ping Pong" and the "Push to Front" patterns for each case, based on the descriptions of section 2.2. To this end, the following R [9] script was developed.

```
#---Evaluate Ping Pong behavior---
PingPong<-c();
#...Loop over traces....(traces contain Support Teams as activities)
Rle<-rle(traceRow)
#Does the case Ping Pong?
PingPong<-c(PingPong,sum(duplicated(Rle$values)))

#---Evaluate Push to Front behavior---
PushtoFront<-c();
#...Loop over traces....(traces contain Lines as activities)
Rle<-rle(traceRow)
#Does the case Push to Front?
if(Rle$values[1]=="1st" & length(tempRle$values)>1){
   PushtoFront<-c(PushtoFront,0)
}else {
        PushtoFront<-c(PushtoFront,1)
}
```

As expected, both behaviors have a negative effect on the case duration. Figure 2 illustrates these effects for the mainstream cases (outliers, i.e. cases that last more than 50000 minutes are removed). While for *Push to Front* a binary variable is sufficient, for *Ping Pong* a numerical scale is preferred. An illustrative argument for this choice is presented in Fig. 3. In this point we shall remind that a Ping Pong is assigned per team, i.e., even if a pair of teams handover their work multiple times during a case, that will still count for two (one for each team that is revisited).



(a) Duration of cases that Push to Front (1) or not (0)

(b) Duration of cases over the number of Ping Pongs they contain

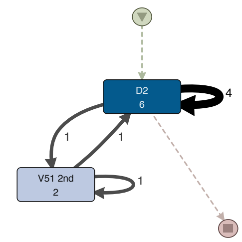
Fig. 2: The effect on case duration

4 Analyzing the Relevance of Factors

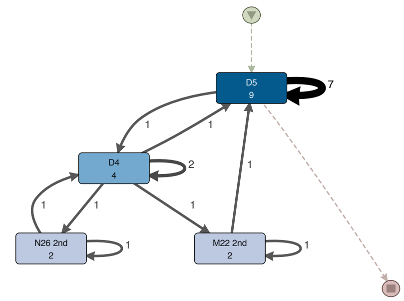
4.1 Discrepancy Analysis

In a case evolving framework, discrepancy measures the between-case variability of the case lifecycle trajectories. Therefore, higher discrepancy, for example, would reflect a greater level of uncertainty about the path followed by the cases. The discrepancy of sequences will be defined from their pairwise dissimilarities. Perhaps the most popular dissimilarity measure used for sequence analysis is the generalized Levenshtein distance. It is defined as the lowest cost of transforming one sequence into the other by means of state insertions–deletions and state substitutions.

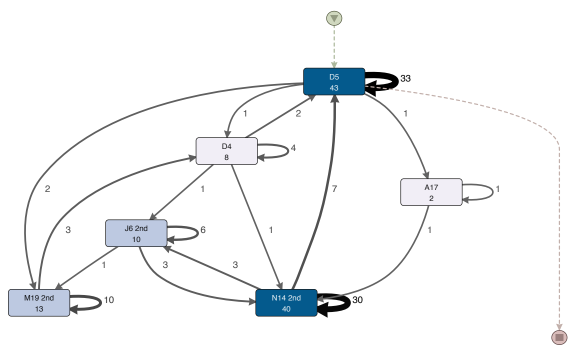
In this section, we integrate the sequence discrepancy analysis with the regression tree method introduced in [10]. The intuition of this regression tree method is the following: Start with all cases grouped in an initial node. Then,



(a) Single Ping Pong



(b) Double Ping Pong



(c) Multiple Ping Pong

Fig. 3: A numerical scale for the Ping Pong behavior is preferable

recursively partition each node using values of another variable. At each node, the variable and the split are chosen in such a way that the resulting child nodes differ as much as possible from one another or have, more or less equivalently, lowest within-group discrepancy. The process is repeated on each new node until a certain stopping criterion is reached. For the implementation of this method, we used the TraMineR [11] package of R.

As illustrated in Fig. 4, both social patterns (Push to Front and Ping Pong) result in clustered behaviors. In particular, the first split is among cases that Ping Pong or not (0 and greater than 0). Cases of the later category (no Ping Pong) last significantly less and visit a lot less frequently the "*Queued*" status. At the second level, leftmost the split is among cases that Push to Front (>0) and not (0). We regard that cases that Push to Front reach a "*Completed*" status earlier, and that their average duration is smaller. The rightmost split is again based on the Ping Pong behavior, but this time the critical value is two. Cases that Ping Pong more than twice spend an important percentage of their lifetime in a "*Queued*" status, and are naturally prolonged.

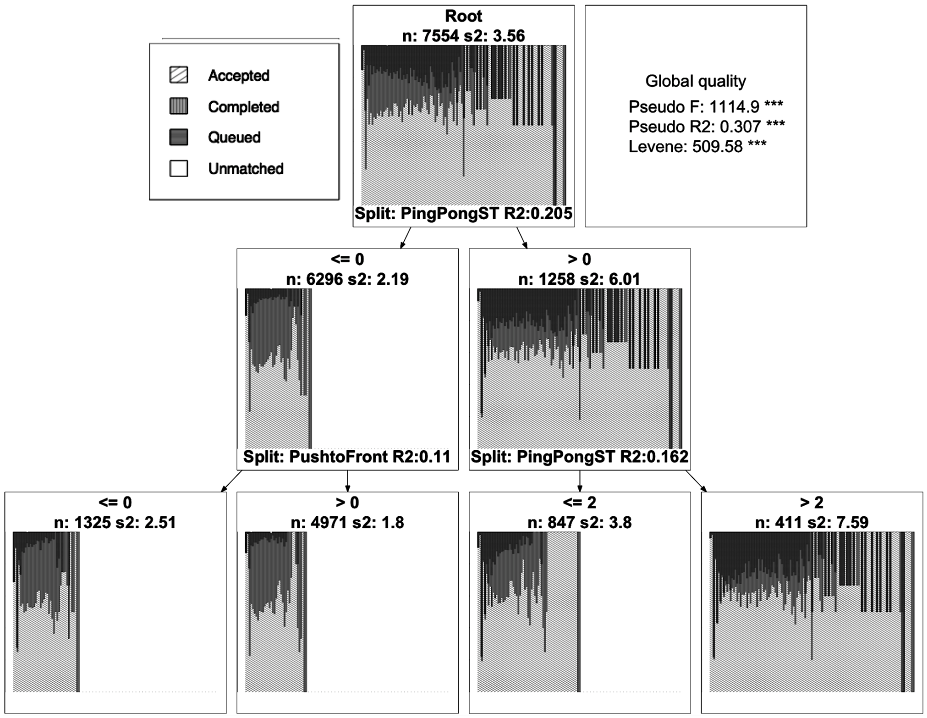


Fig. 4: Discrepancy Analysis for cases lifecycle trajectories

4.2 Binary Classification

Support Vector Machines (SVM) is one of the most well-known supervised classification algorithms. It was originally proposed by Vapnik [12]. The intuition of SVM is that the goal is to get an hyperplane that optimally distinguishes two classes of data. The major advantage of SVM is its minimal generalization error (at least in the case of binary classification - two classes of data) reached computationally efficiently. The SVM is one of the most applied algorithm of robust optimization in data mining. For a thorough exploration of theoretical and practical issues, we cite the classic work [13] and the works of Trafalis et al. [14] and Xu et al. [15]. We used 10-fold cross validation on a training data set of case-label pairs $(x_i, y_i), i = 1, \ldots, 7$, where $x_i \in \Re^n$and $y \in \{-1, 1\}^7$. Number 7 indicate that seven factors (Country, Impact, Line, Function, Organization, number of Events and Push to Front) were examined to predict the Ping Pong behavior. We used a linear kernel, as implemented by the LIBSVM library [16]. The overall accuracy of the model (for all folds, both classes) was 89.48%, but what is more important is to try to explain the factors that appear to be the most critical. According to [17], in linear SVMs, the use of w_i^2 can be justified as a feature ranking criterion. Therefore, the following interesting points emerged:

- We identified that there are 3 countries (China, Sweden and U.S.A.) whose support teams are more prone to Ping Pong.
- The impact of cases does not appear to have an effect
- Ping Pong appears the most when cases are initiated in the front line.
- There are some particular Function Divisions and Organizations that are more prone to Ping Pong behavior
- Pushing to Front seems to have a negative impact
- As expected, the number of events per case is the most critical predictor of Ping Pong behavior

Overall, this paper applied a process mining approach to explore a real case study with the goal to provide insights to this implicit business process and to raise the capability of the company to handle service requests. The results presented in the previous sections allow the company to reach evidence-based response policies. In addition, since the identified issues are localized (certain support teams, certain divisions etc.), the evidence provided could aid company's decision about the teams' structure.

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Fostering Priority Awareness to Improve Joint Outcomes in Computer-Supported Bilateral Multi-Issue Negotiations

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Abstract. Bilateral multi-issue negotiations rarely lead to optimal results for the negotiators. A reason could be the missing knowledge about the priorities of the negotiation parties. Building on the foundation of Knowledge and Information Awareness – where group members are informed about the knowledge and its underlying information of their collaborators, leading to better computer-supported collaborative problem solving – this experimental study seeks to expand these findings on Priority Awareness: the knowledge of one negotiation party about the priorities of the other negotiation party. One hundred thirty-two participants were randomly assigned to dyads of an experimental condition with Priority Awareness or a control condition without Priority Awareness using an E-Negotiation System to negotiate in a car selling/buying scenario. Results show that the experimental condition had a marginally significant higher impasse rate than the control condition, and a significantly higher joint outcome in the mean of 12%. Implications of these findings are discussed.

Keywords: priority awareness; bilateral negotiation; multi-issue negotiation; integrative negotiation; visualization; graphical decision aids; ENS

1 Introduction

Negotiations between two (or more) parties do not only play a central role in peace negotiations or long-term trade agreements with far-reaching political and financial implications, but also in many areas of everyday life. In such bilateral negotiations, the negotiators involved rarely achieve an optimal result which integrates all their different interests to a maximum [1, 2].

The *fixed-sum error* and the subordinate *incompatibility error* are exemplary reasons for suboptimal negotiation [2]. The fixed sum error refers to the tendency of one negotiator to assume that the other negotiator has the same priorities. The incompatibility error refers to the fallacy that one negotiator believes that the interests of the other negotiator would not be compatible with his or her own, even when they actually are. Both fallacies have an underlying lack of knowledge about the priorities in common with the other party, thus limiting an integrative negotiation [1–4].

While single-issue negotiations – or multi-issue negotiations in which individual issues are negotiated independently as satisfactorily as possible – are purely distributive in nature, the availability of multiple issues creates at least the possibility of an integrative negotiation [5]. In the case that differences exist between the parties in terms of the priorities of the individual issues, an integrative solution can be found: The parties grant concessions on less important issues and in turn receive concessions on more important ones. Thus they achieve a higher joint outcome through these trade-offs than if they had made an equal split for each individual issue [6].

1.1 From Knowledge and Information Awareness to Priority Awareness

The fostering of *Knowledge and Information Awareness* [e.g. 7] has shown to enhance the effectiveness and efficiency of newly formed groups of experts in network-based collaborative problem solving tasks. Knowledge and Information Awareness refers to the knowledge of spatially separated group members about their collaborators with regard to their structures of knowledge and the underlying information. These findings could be extended to another type of awareness, namely, to *Priority Awareness*: This entails informing one negotiation partner about the priorities of the other negotiation partner that he or she has with respect to the issues to be negotiated.

Similar to the results of Engelmann & Hesse [7] on Knowledge and Information Awareness, studies have shown that knowledge of the priorities of the other party lead to more integrative negotiations and to a higher joint outcome either because one party asked, unsolicited, for the priorities [1, 2], or priorities were estimated computer-aided [3], or converted into utility values and displayed in a graph [4]. On the other hand, a lack of knowledge about the priorities of the other party does lead to a higher rate of the fixed-sum error and, therefore, in less joint outcome [2] or even in a “lose-lose” agreement in which compatible interests are not recognized as such and both parties agree on a common loss [8], even when negotiators are experienced [9].

1.2 Computer-Supported Negotiation

Since negotiations can play a such crucial role in the fate of many people and the gain and loss of large amounts of money, the supportive use of computer systems in complex negotiations has been a subject of study in recent years [10]. Such *Negotiation Support Systems* (NSS) or web-based *E-Negotiation Systems* (ENS) are of different types and offer support in various stages of negotiations [10]. Taking the study by Vetschera, Kersten, and Koeszegi [11] as an example: First, the individual issues, their available options, and the preferences for the these options are requested by the system. Utility values are calculated from the chosen option of each issue for every given package offer and then used to evaluate every offer during the negotiation phase. After the negotiation phase, the utility values serve to optimize the negotiated agreement. It has been shown that the usage of a NSS leads to a higher individual [12] and joint outcome [3, 4, 12, 13].

1.3 Difficulties of Prior Negotiation Visualizations and a Problem-Solving Approach

In addition to the tabular representation of preference or utility values calculated in NSS/ENS, visualizations were also used in negotiation studies (for an elaborate categorization of graphical decision aids, see the paper by Gettinger and Koeszegi [14]).

In hindsight to Priority Awareness, the graphical decision aids of previous studies have diverse shortcomings: Rangaswamy and Shell [15] only visualized each party's own information on priorities in bar charts, but not that of the other party. The bar chart was an integrated part of their NSS, but it was not further examined. Weber, Kersten, and Hine [16] used history graphs which, besides being hard to understand, lack a finer grain of information by visualizing only the utility values of all given package offers. The study by Gettinger, Koeszegi, and Schoop [4] compared the representation of utility values in a history graph with that of a negotiation dance graph, the latter going back to the works of Raiffa [17]. Negotiation dance graphs visualize the utility values of all package offers from the perspective of both parties and provide useful information for the skilled practitioner to analyze a negotiation. Like history graphs, they unfortunately process information on an abstract level (utility values of package offers) and visualize two parties in one diagram: This is harder to understand for people who do not negotiate on a regular basis or who are not directly involved in negotiations [14]. The results of the study by Gettinger et al. [4] show that the additional visualization of the utility values of the other party lead to higher joint utility and more balanced agreements than the mere visualization of each party's own utility values.

All these studies have different shortcomings and this experimental study was designed to address them.

2 Experimental Study

This experimental study utilizes bar charts as one way to foster Priority Awareness. The intention is to overcome the described shortcomings of graphical decision aids in computer-supported negotiations and to boost the number of agreements as well as the joint outcome. The potential use of bar charts to visualize priorities of issues has been discussed by Weber et al. [16]. Bar charts offer an easily accessible approach to information and are commonly used around the world, from regular newspapers to scientific articles. This visualization differs in the type of information and its potential use from history and negotiation dance graphs in so far, that the latter visualize utility values which represent an integration of every chosen option of each available issue inside one made package offer. This results in a trial and error search for integrative issues. Priorities however, are the issues ranked by their importance (where to gain/lose most) and thus support integrative negotiations. This ranking of preferences is also part of the approach of the evaluation of two-party integrative negotiations by Raiffa et al. [17], although they do not define priorities.

Measuring joint outcome is standard in negotiation studies and as previously stated, more knowledge of the other parties' priorities leads to a higher joint outcome [1–4]. The individual outcome does not give insight on the exploitation of integrative potential. Although measuring the impasse rate has increased in current negotiation studies [18], findings on the knowledge of the other parties' priorities and impasse rates are very rare. It is assumed that Priority Awareness leads to a higher joint outcome and a lower impasse rate because the visible priorities of the other negotiator lead to a higher recognition of integrative potential, and thus to more advantageous trade-offs for both parties. Therefore, two hypotheses will be explored in this paper:

Hypothesis 1: Dyads with Priority Awareness have a lower impasse rate than dyads without Priority Awareness.

Hypothesis 2: Dyads with Priority Awareness have a higher joint outcome than dyads without Priority Awareness.

3 Method

Participants. 131 university students from different fields of study and one social worker participated voluntarily in this experiment for payment (69 female, 63 male, M_{age} = 24.96, SD_{age} = 7.31, age range: 18–62). Among these were 22 business students. The participants were randomly assigned either the role of a car retailer or a potential buyer, resulting in 66 dyads. These dyads were randomly assigned to the experimental condition or the control condition, resulting in 33 dyads per condition. The composition of gender in the dyads, the level of acquaintance, the age, and the prior knowledge of computers, tables, and bar charts did not differ between the conditions. Already excluded from these numbers are two dyads whose participants had serious problems understanding the task at hand and did not generate valid data to be included in the calculations.

Material and Procedure. A modified version of the payoff schedule of Thompson and Hastie [2] was used in this experiment. A full description of the payoff schedule can be found there. The point values of the options (the negotiators preferences of the options as a numerical value) and their distributions were not changed, however, some of the eight issues (4 integrative, 2 distributive, 2 compatible) and five respective options had to be modernized such as, for example, the issue "Radio" with its options "AM/FM" or "AM/FM/Tape +" (a comprehensive list of changes can be requested from the author). The sum of the individual point values can hypothetically result in a range of -3600 to 13200 points of joint outcome.

The experiment lasted approximately one hour and took place completely in an specifically build experimental ENS, running on separate computers in different rooms. Both negotiators worked separately at their own pace until the negotiation phase where one negotiator had to wait for the other until the ENS would let them proceed. After the negotiation phase, both negotiators worked separately once again.

The experiment began with an anonymous questionnaire about personal data (e.g. age, gender, prior knowledge of bar charts/tables/computers, field of study), followed by other control measure questions on personality traits. Except for three questions, which were assessed by five-point rating scales ranging from 1 point for no agreement and 5 points for complete agreement, all other questions were measured by an equivalent four-point rating scale. Then the scenario and the negotiation interface were presented and questions about the understanding of one's priorities were asked. That both parties will negotiate for points and that their goal is to maximize their individual points was explained twice by the ENS to curb the intrinsic motivation to win [19]. Following this, the negotiation phase started and the negotiators had 35 minutes to reach an agreement. The negotiators would either be forwarded to the next experimental phase after the time ran out or one negotiator pressed the continue button. Besides using the ENS to choose options, the negotiators could freely communicate through Skype (only audio and only for the duration of the negotiation phase). Subsequently, a question on whether the parties had reached agreement was presented to each individual negotiator and questions about the priorities of their negotiation partner. Following this, was a questionnaire which asked different questions on frequency, satisfaction, effort, fairness, honesty, and skills with regard to the negotiation, and the other negotiator, as well as questions on the utility of the bar chart and the frequency of usage. In addition, several other variables were recorded, such as the duration of the negotiation, the selected options until the agreement, and the conversation.

Figures 1 and 2 show the ENS in the negotiation phase exemplary of the car retailer (because this experiment was held in Germany, all presented screenshots were translated). The negotiators in the control condition saw a bar chart in the upper half of the screen, representing only their own priorities (Fig. 1). The bigger the bar, the more points they could maximally gain/lose with an issue and therefore the higher the priority of an issue. In the lower half of the screen they saw the eight issues to be negotiated with their respective five options and their own point values accompanied by radio buttons which could be activated by either negotiator. In case of the buyer not accepting an offer, he or she could click freely on another option. The negotiators in the experimental condition saw a bar chart in the upper half of the screen representing their own priorities as well as the ones of the other negotiator (Fig. 2). In addition to this, there were no differences to the control condition. Again, both parties only saw their own point values in the lower half of the screen.

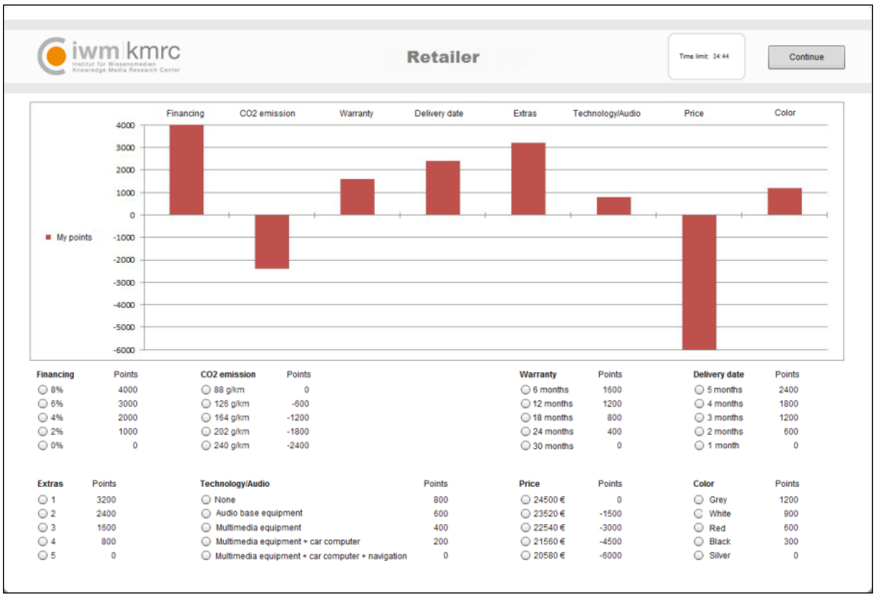

Fig. 1. Negotiation phase in the control condition without Priority Awareness (exemplary for the car retailer).

Fig. 2. Negotiation phase in the experimental condition with Priority Awareness (exemplary for the car retailer).

4 Results and Discussion

There were no differences in the control measure questions on age, gender, prior knowledge of bar charts/tables/computers, field of study, and the personality traits between the conditions. All dyads that had reached an impasse were excluded from the outcome calculations, that is, not having agreed on a set of options and therefore not having reached a point score. This leaves this calculation with 60 dyads in total.

The analyses on the differences in the impasse rate as well as the joint outcome between the conditions are based on group level data because the individuals in a group were not independent of each other.

The number of agreements differed marginally significantly between the conditions: Contrary to Hypothesis 1, there was one dyad with Priority Awareness that did not reach an agreement, while there were five dyads without Priority Awareness that did not reach an agreement (χ^2 (1, N = 66) = 2.93, p = .087, φ = .21). An explanation for this finding could be that being aware of the priorities of the other party would in fact make the integrative potential of the negotiation visible, but the possible unwillingness of one negotiator to make concessions would lead the other party to bail out of the negotiation. Considering the low total number of the impasses, this result can only be interpreted in a descriptive way. Transcripts of the audio recordings are being generated and will be examined to further explain this finding.

In line with Hypothesis 2, dyads with Priority Awareness agreed on a significantly higher joint outcome (M = 9793) than dyads without Priority Awareness (M = 8775, $t(58)$ = 2.05, p = .045, d = .53). The difference between the conditions averages to 12% with a moderately high effect size. A bigger difference between the conditions could have been found, if the participants were less heterogeneous in age and field of study and were more experienced in negotiations: On the 4-point Likert scale question "I have often negotiated before participating in the study" the participants stated with M = 2.39 "does rather not apply". Considering the truthfulness, both conditions rated the question "I acted openly and was honest to my negotiation partner" with M_{EC} = 3.05 and M_{CC} = 3.29 "does rather apply". Anyway, the higher joint outcome speaks for the effect of Priority Awareness in computer-supported negotiations and further strengthens the advice to share one's information about priorities in negotiations [20] and in a wider sense, their full, open, truthful exchange [17].

More analyses are needed to fully elaborate the effects of Priority Awareness on such outcome measures of negotiations – besides the impasse rate and the joint outcome – as the pareto efficiency, the satisfaction, the fairness and the duration. The transcripts of the audio recordings also present a multitude of to be evaluated process variables. On top, bar charts have shown to have some drawbacks in their simplicity: Some participants seemed to have had problems understanding the meaning of the bar chart in the beginning but then seemed to have grasped it in the negotiation phase. This will be addressed in future studies by using a slightly modified bar chart. It is also planned to foster Priority Awareness with a partial, open, truthful exchange [17] of priorities, where a full disclosure is not needed, as this is not always the case in real negotiation settings.

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Incorporating personal style into a Negotiation Support System

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Abstract. This paper presents a proposal to incorporate the personal styles of negotiators into a Negotiation Support System. The Myers-Briggs Type Indicator (MBTI) model was implanted in an e-negotiation system to capture some personal styles of negotiators, starting from the hypothesis that some prior knowledge about the negotiator helps to improve the negotiation in terms of the satisfaction and communication of the actor involved and the time to completion of the negotiation. Experiments are being conducted on a developed platform that incorporates the MBTI to accept or reject this hypothesis.

Keywords: Negotiation support system, e-negotiation, Myers-Briggs Type Indicators, personal style.

1 Introduction

This paper presents the initial results of a research study in progress. From the literature review it is observed that in many situations whenever a negotiating process is absent from face-to-face negotiating supported by a Negotiation Support System (NSS), the process is more time consuming and the results sought by the negotiators are not achieved, thus generating dissatisfaction with the negotiation. This indicates that optimizing the parties' use of time and satisfaction are key factors for a good negotiation [1].

The literature suggests that incorporating communication strategies into the process can facilitate understanding the information presented by each negotiator thereby helping to improve the interaction between those involved [2]. Lack of knowledge of other stakeholders also hinders communication and negotiation. [3].

Drawing on the literature, this paper starts from the premise that one way to minimize the difficulties reported in a negotiation process supported by a NSS is to provide some knowledge about the personality characteristics of the negotiators.

Thus, a model to capture the style of an individual personality was chosen and was incorporated into an NSS developed for this purpose. In addition to this functionality, the proposed NSS evaluates, at the end of negotiation, the quality of communication, the satisfaction of those involved and the duration of the negotiation, thus enabling it to be inferred that if one party knows the personality traits of the other party in a negotiation process, this contributes to a good negotiation.

2 Literature Review

The first Web-based NSS found in the literature was INSPIRE which has been tested and used in teaching and training in several countries [4]. Since then, it has been common to find different NSS (Negotiation Support System) [5] [6] [7] and also the development of studies on the effects and influences of these systems on the negotiation process [8] [9] [10].

Kersten and Lai [10] present a historical overview of software used in supporting Negotiations and propose a distinction between two generations of negotiation systems: NSS designed for a stand-alone computer or a local-area network and ENSS in which systems use internet technologies. They discussed these categories from three perspectives: real-life applications; systems used in business, research and training; and research results.

As an example of empirical studies using NSS, Szpakowicz and Sokolova [9] explored how influence strategies are reflected in the language of e-Negotiations systems. *The results show that language signals influence strategies and tactics ; the authors* give a reliable prediction of the negotiation outcome based on the first half of the negotiation.

The web-based negotiation support system (NSS) Inspire also has been used in experimental Negotiations by over 2000 negotiators worldwide. As a result of a survey conducted among users, it was verified that users' assessment on complex and analytical features of web-based NSS are evaluated differently from communication features between various components of such systems. Assessments along these dimensions are strongly influenced by users' national culture [8].

Zandi and Tavana [6] propose a fuzzy electronic negotiation (e-negotiation) support system based on multicriteria cooperative game theory. The Internet is used to facilitate the e-negotiation process and to minimize the response time in the decision-making process. The objective of this study was to integrate multicriteria fuzzy cooperative game theory and Internet technologies within a collaborative e-negotiation support system .

In this research, in a similar way to other studies, we seek to investigate how knowledge of negotiators' personality traits can influence the outcome of the negotiation in terms of improve satisfaction, communication and time.

Many models can be found in the literature to identify personality traits [11] [12] [13] [14] [15]. However, to capture the personality traits of the individual to be incorporated into an NSS what is needed is a model that can be implemented quickly and which at the same time is robust and has already been extensively tested. From these assumptions, the model chosen for this study is the Myers-Briggs Type Indicator (MBTI) [11] [12]. MBTIs identify an individual's personality styles by combining four dimensions obtained from responses to a questionnaire. The dimensions are extroversion and introversion; Sensing and Intuition. The intensity in each dimension represents the spectrum of an individual's personality in which there are sixteen combinations in total.

The MBTI questionnaire comprises 28 forced-choice questions i.e. the respondent has to choose only one of two possible answers to each question. After the questionnaire has been fully completed, the individual traits of personality are assigned to a category defined by the four dimensions considered in the model.

Other models [13] [14] [15] found in the literature have the same purpose as the MBTI, but in most of them, the questionnaires contain a large number of questions that make the negotiation procedure difficult and do not include a dimension related to how the decision maker came to his/her decision.

Drawing on the literature cited above, this article sets out it to test the following hypotheses:

H1: knowledge of personality traits of the other negotiator in a negotiation process supported by a web NSS improves negotiator satisfaction at the end of negotiation, in the perception of the negotiator.

H2: knowledge of personality traits of the other negotiator in a negotiation process supported by a web NSS improves communication in the negotiating process, in the perception of the negotiator.

H3: knowledge of personality traits of the other negotiator in a negotiation process supported by a web NSS reduces the time to complete the negotiation.

Although the MBTI has also been criticized [16] in the literature, it serves the objectives proposed for this study satisfactorily.

Research Method

The purpose of this research is to evaluate whether or not knowledge of personality traits of other negotiators influences the level of satisfaction, communication quality and time needed to conduct the negotiation.

To accomplish this, we developed the NegPlace (www.negplace.com), a NSS web based technology that incorporates the MBTI [11] model and provides negotiators with (some of the) personality traits of those involved, thus enabling the actors to have prior knowledge of each other.

Fig 1 shows the research model to be explored.

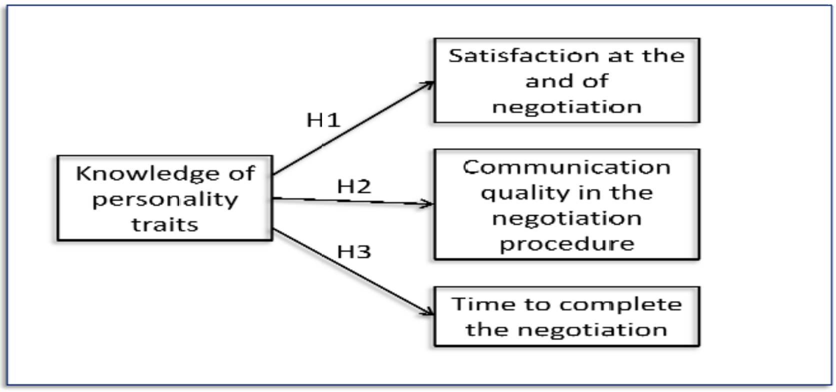

Fig. 1. Research model

In the current phase of the research, an experiment with undergraduate and graduate students is being conducted in which they will be involved with a predefined negotiation using the NSS.

Some students, randomly selected, use the NegPlace system with information about personality traits of the other negotiator while other students do not.

The constructs of satisfaction and communication will be assessed by a constructed attribute from a questionnaire to be answered at the end of the negotiation. The duration of negotiation will be measured directly by the NegPlace system.

Initially the system only allows negotiations in pairs, although any one negotiator can participate in multiple negotiations.

A new version of the system is being developed in which negotiators can access the system via the internet, register and start negotiations, and invite other actors to negotiate or enter into negotiations of interest already begun. The idea is to provide free access to the system to any person anywhere in the world.

The system will randomly choose a user who will be provided with the functionality of personality traits of the other negotiator.

The NegPlace environment

The NegPlace is a web NSS which has the following features: it registers the negotiator, the participation in a negotiation, offers and counter-offers in a negotiation process, and the access given to information on personality traits of negotiator.

On registering as a new system user, he/she must answer a questionnaire based on the MBTI model that will provide information about the personality of the other negotiator. Some personality traits that may contribute to the negotiation process will be captured and exhibited on the system.

Such information may help negotiators to define the negotiation strategies to be adopted and also the resources to be selected, such as: videos, texts, in order to submit offers and counter offers to improve the communication process.

At the end of the negotiation process, the negotiators should fill out another form that will assess the constructs presented in the research model. This enables the hypotheses proposed to be tested.

The next steps are to conclude the first controlled experiment with students and analyze the data collected. Thereafter, a new version of the system will be drawn up and the data collected will be analyzed using the revised NSS in experimental negotiations.

Conclusion

This paper proposes an exploratory study to evaluate the influences of one negotiator having knowledge of some personality traits of another negotiator on the results of a negotiation supported by a Web NSS.

NegPlace, the system that embeds the MBTI model which captures the traits of personality was developed. A theoretical model was put forward which will test three hypotheses. Initially, a controlled experiment is being conducted using undergraduate and graduate students. In parallel a new version of NegPlace is being constructed that will enable anyone anywhere in the world access this system and register on it. The objective is to ascertain what effect the knowledge provided about unknown actors, which negotiators receive about each other, has on a negotiation process, supported by a web negotiation system.

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Agenda Negotiations in Electronic Negotiation Support Systems– Complexity versus Flexibility

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Abstract. The focus of current negotiation research is on the core negotiation process disregarding the role of the agenda in negotiations. According to the characteristics of negotiations, the creation and handling of issues is defined representing the flexible but also very complex nature of negotiations. In this article, the concept of task-technology fit is applied to the domain of agenda negotiations, which require systems to support behavioural flexibility albeit being counterbalanced by an increased task complexity. To this end, we conducted an experiment alternating the level of flexibility and analytic decision support. The results show a consistent interaction between negotiators' flexibility and the provided decision support. Decision support helps negotiators in a more flexible and complex negotiation environment to achieve more efficient and balanced outcomes as well as to express a better system experience.

Keywords: agenda negotiation, task-technology fit, task complexity, flexibility, technology acceptance

1 Introduction

Negotiations are characterized by iterative communication and decision making processes. Whilst the use of electronically supported negotiations has increased over the last decades to a common form of business and private interaction [1], the development of several negotiation support systems (NSSs) has not led to the expected trend of mass usage.

A possible lack of task-technology fit (TTF) might be one reason for the low acceptance of NSSs. Prior research has shown that TTF is an important antecedent of users' behavioural intention to reuse information systems (IS) and for actual usage behaviour [2]. However, in contrast to the traditional focus on individual user behaviour in IS research, research in the area of NSS has to consider the larger picture including all parties involved in the conflict resolution process [3].

The iterative process characteristics of negotiations and the underlying mixed-motive tasks require NSSs to provide their users with a high level of flexibility. Integrative negotiation behaviour is conceptually and empirically linked with higher joint gains, more balanced outcomes, and higher negotiation satisfaction [e.g. 4]. Such negotiations require negotiators to compose and de-compose the issues under discussion. The task of handling issues is typically conducted in the pre-negotiation phase. However, negotiators have little information about the preferences and goals of their partner(s) at the very beginning of a negotiation before exchanging offers and thereby preference information. Therefore, negotiators need the possibility to change issues also *during* the negotiation process [5].

Currently, most NSSs do not provide users with such flexibility in handling issues. Whilst an NSS providing such flexibility creates a fit between the task characteristics and the offered support, a higher level of task flexibility increases the level of task complexity [6]. Therefore, the present paper aims to investigate (i) whether a higher flexibility of users dealing with a flexible negotiation agenda improves objective outcome dimensions and (ii) whether the increased task flexibility is reflected in subjective perceptions of using the NSS.

2 Theoretical Background

On the substantive dimension, the negotiation process can be divided into agenda and value negotiations. Agenda negotiations are the joint effort of the parties to specify the issues to be resolved in the later negotiation process. Value negotiations are the joint effort to combine the parties' conflicting positions in a joint agreement. Traditionally, agenda negotiations are set in the preparation phase of the negotiation followed by value negotiations. However, due to a limited awareness and knowledge of each other's preferences [7], negotiators often fail to exploit the full integrative potential of the conflict situation. The exchange of mutually beneficial and Pareto-improving steps (such as log-rolling or linking and de-linking issues) requires the consideration of both parties' preferences [8]. Accounts of what is "left on the table" and what is fair can only be made knowing each other's preferences once all possible issues are on the negotiation table. Furthermore, parties might also want to change issues during discussions [9], might realise that the issues on the table do not reflect underlying interests and needs or that congruent issues actually exist.

The concept of TTF postulates a fit between the characteristics of a task and its supporting technology to lead to higher individual performance and to increase actual tool usage [2, 10]. In group support systems, a better joint performance depends on the fit of the group support functions and the complexity of the task [11, 12]. The more complex a task, the more support is required; the simpler a task, the lower the need for support [11]. Consequently, NSSs reflecting characteristics of negotiations need to enable a flexible iterative negotiation process with negotiators being able to switch between phases of agenda and value negotiations. This flexibility allows negotiators to shape the process according to their needs and to create a fit between the characteristics of the task and the support provided which should result in a better group performance, measured e.g. through process quality and outcome quality [11]. Turning to objective measurements of negotiating groups, performance of negotiation dyads are reflected by higher efficacy, efficiency, and balance of agreements. Therefore, our first research question is formulated as follows:

RQ 1: Does a higher flexibility in handling agenda negotiation processes improve objective negotiation outcome dimensions?

TTF shows that a fit between the characteristics of the task and the provided support positively shapes actual tool usage [12, 13]. Based on the characteristics of negotiation tasks, usage and acceptance of an NSS are restricted when the necessary flexibility of the process is restricted. Missing flexibility or the missing possibility to change and adapt will frustrate users [14]. Moreover *"...if a group support system imposes structure on the task to the extent that the task is modified to fit the tools or agenda enforced by the GSS, it is possible that the assigned task may not be the one actually performed by the group*" [11]. A fit between the task and the provided technology shapes users' perception of the perceived usefulness and ease of use of a system [13]. A substantial perceived ease of use as well as the perceived usefulness are important prerequisites for actual system usage [15].

While we expect several substantial positive effects by increasing the level of flexibility, we cannot neglect possible negative effects. By increasing the number of ways linked with uncertainty to arrive at the desired agreement, we also increase the level of task complexity [6]. An increased task complexity results either in an increase in decision time, a decrease in decision accuracy and/or decision quality, and, consequently, a decrease in users' confidence [e.g. 16].

Therefore, the increase of both task flexibility is expected to positively shape negotiators' experience with the NSS whilst the increase in task complexity is expected to negatively shape negotiators' experience with the NSS. We formulate our second research question accordingly:

RQ2: Does a higher flexibility in handling agenda negotiation processes counterbalance possible negative effects of an increased task complexity regarding negotiators' system experience?

3 Experimental Evaluation using the Negoisst system

To answer our research questions, an experiment with 170 graduate students from two European universities using the negotiation support system Negoisst was conducted. Negoisst follows a holistic support paradigm including decision support, communication support, and document management [17, 18]. Decision support (DS) is based on multi-attributive utility theory and individual feedback is given to its focal user in form of utility values. Communication support in Negoisst is implemented by an asynchronous exchange of offers containing text messages as well as an instantiation of the negotiation agenda. The text messages are semantically and pragmatically enriched to prevent misunderstandings and to convey the mode of the utterance. In our laboratory experiment, the students negotiated a bilateral negotiation case over 14 days. Participants followed negotiation courses at their respective universities with grades as incentives and answered pre-questionnaires and post-questionnaires treating our respective research questions. Students were assigned to treatments differing along the dimensions of provided decision support and/or a provided flexible agenda protocol as shown in table 1. No decision support means that neither utility values nor a history graph are provided for the negotiators. The flexible agenda protocol enables an arbitrary number of agenda negotiations whilst the fixed agenda protocol only permits one agenda negotiation at the start.

n = number of dyads		**Agenda-Protocol**	
		Fix	**Flexible**
Decision Support	**DS**	n=18	n=19
	No DS	n=15	n=12

Table 1. Treatments

4 Results

We analyse the impact of our treatments in a holistic manner by considering subjective as well as objective dimensions. The subjective dimensions are based on constructs from literature considering negotiators' perceived ease of use, usefulness, and behavioural intention to reuse the system in the future [15, 19, 20], and adopted for the NSS context of our study. The objective negotiation outcome dimensions are calculated based on information stored by the system.

Regarding RQ1, our results reveal no impact of our treatments on the likelihood of finding an agreement ($p = .949$). In contrast, agreements per se reveal a consistent interaction between the used protocol and the use of DS (see table 2).

Negotiation dyads reaching an agreement and following the less complex fixed agenda protocol have a higher tendency to reach Pareto efficient agreements when they are supported with DS compared to negotiators without DS support ($p < .1$).

Analyses of the non-efficient agreements reveal that the use of DS has no influence on the distance of the agreements to the Pareto frontier when negotiators are using the fixed agenda protocol ($p = .424$). In contrast, the use of DS substantially reduces the distance to the Pareto frontier when negotiators are using the flexible protocol ($p < .05$). Therefore, the quality of non-efficient agreements was increased when negotiators were supported with DS and followed the flexible agenda protocol. Similarly, fairness of agreements (i.e. low contract imbalance) was higher when negotiators were supported with DS in the flexible agenda protocol treatment groups ($p < .01$), but not when they were following the fixed agenda protocol ($p = .986$).

Turning to the subjective dimensions (RQ2), a similar picture is revealed for the interaction between the used protocol and the use of DS. Independent of the use of DS, negotiators expressed similar levels of perceived NSS usefulness for the support of the negotiation process ($p = .322$) and for the outcomes ($p = .670$) when following the fixed agenda protocol. In contrast, the use of DS increased negotiators' perceived usefulness of the system to support the process ($p < .05$) and outcomes ($p < .1$) when negotiators followed the more complex flexible agenda protocol. Similarly, negotiators' perceived ease of using the NSS is not influenced by the use of DS when following the fixed agenda protocol ($p = .172$). However, negotiators using the flexible protocol perceive the system to be easier to use when supported by DS ($p < .01$). Prior results are also reflected in the negotiators' behavioural intention to reuse the system in future negotiations. For the fixed agenda protocol, negotiators with or without DS express an equal behavioural future intention ($p = .852$). On the other hand, negotiators following the flexible negotiation agenda express a higher intention to reuse the NSS when DS was available ($p < .05$).

Treatments	**Agenda-Fix, no DS (T1)**	**Agenda-Fix, DS (T2)**	**Agenda-Flex, no DS (T3)**	**Agenda-Flex, DS (T4)**
Agreements	12	14	9	16
Agreement rate	80.00%	77.78%	75.00%	84.21%
# Efficient*	1	6	1	2
Distance to Pareto-frontier*	6.79 (3.19)	4.54 (4.47)	10.46 (7.31)	4.90 (4.48)
Contract Imbalance*	14.33 (13.87)	14.43 (10.78)	23.33 (9.96)	10.06 (6.77)

Table 2. Objective Outcome Dimensions, *agreements only

5 Discussion & Conclusion

The current paper discusses the interrelation of complexity and flexibility in negotiation support systems. Negotiation itself is a highly complex task that requires sophisticated support for human negotiators. Negotiation support systems offer such support by different means, e.g. decision support and communication support. It has been shown that the task and the technology have to fit to achieve the envisaged results.

In this paper, we transferred the task-technology-fit paradigm to electronic negotiations. We discussed agenda negotiations as a specific form of negotiation that can occur at different times during the negotiation process. To find out whether a flexible support of agenda negotiations leads to improved negotiation results and whether there are interdependencies between task complexity and system flexibility, a negotiation experiment was conducted.

Our results show a consistent interaction pattern along subjective and objective dimensions. We show that allowing flexibility in performing the agenda negotiation process, which was operationalised by a flexible agenda negotiation protocol, benefits from structured decision support, i.e. enabling flexibility and providing complexity reduction at the same time. In contrast, when following the fixed agenda, a structured decision support only partially improves objective negotiation outcome dimensions, while not shaping negotiators' subjective experience with the NSS. Consequently, the full potential of decision support is shown in more flexible and thus more complex tasks, reflecting a proper task-technology fit. In line with our results, future research will further consider which negotiation characteristics require which level of support.

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Trust and Understanding in Face-to-Face and Synchronous Online Negotiations

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Abstract. This study investigates to what extent the synchronous character of chat communication overcomes the problems in creating mutual understanding and trust between conflicting parties. An experimental study was conducted in which participants negotiated with a confederate in either a face-to-face or online setting. The results show that negotiators feel equally understood and trusted by the other party in both conditions. However, their own ideas about understanding and trusting the other party are higher after a FtF negotiation than after an online negotiation.

Keywords: Negotiation, Synchronicity, Online Face-to-Face, Trust, Understanding

1 Introduction

In negotiations two essential factors for a mutually acceptable resolution are *understanding* and *trust* [1,2]. The sources of conflict are mostly misunderstandings or failures of communication, rather than fundamental differences of interest [2]. In addition, trust is a key factor for negotiators in their decision to share information [3]. Without trust, individuals are more inclined towards competitive behavior [4, 5]. Trust is generally known to be a prerequisite to cooperative behavior and information sharing [6,7,8] and ultimately to a mutually beneficial outcome.

The upcoming of the Internet and digital communication have increased the popularity of online communication for all kind of purposes, including negotiations. Different studies have shown that feelings of mutual understanding and trust suffer from these online developments [7,8,9]. The relative anonymity and safety of the online environment give easily rise to flaming and other negative forms of communication [10]. The lack of social cues such as facial expressions, gestures, posture, voice tones and eye contact in online communication can negatively influence the feelings of trust since people heavily rely on these indicators when assessing another's sincerity [11]. When non-verbal information is unavailable, negotiators tend to engage in bluffs, exaggerations and lies [12] which in turn violate feelings of trust for both parties. Studies of online negotiations confirm the greater challenges for rapport building in e-negotiations in comparison to face-to-face (FtF) negotiations [8, 13]. The study by Thompson and Nadler [14] demonstrated that negotiations by e-mail suffered from different biases that hampered successful rapport building. Like ordinary e-mail communication, e-mail negotiations are prone to a greater risk of burned bridges, because of the emotions that stay visible in the message. Other biases that Thompson and Nadler studied were the squeaky wheel bias, the temporal synchrony bias and the attribution errors that occurred more often in asynchronous e-mail negotiations. The question arises to what extent the greater challenges for relationship building in online negotiations are related to the synchronous character of the medium. Whereas negative emotions in FtF communication can be handled directly and even kept within limits, the emotions expressed in an e-mail, remain unchanged, and possibly even gain in strength over time. Negotiations conducted by synchronous chat should suffer less from these dangers. We do not know of studies that systematically compare rapport building in chat-negotiations to FtF negotiations and the present study aims at filling that gap. The central research question in our study is therefore to what extent the synchronous character of chat communication overcomes the problem in rapport building between participants in e-mail negotiations as reported by Thompson and Nadler. More precisely, we focus on the effect of chat on the trust and understanding a negotiator experiences compared to negotiators in FtF-settings. In this context, the following hypotheses will be tested:

H1: Negotiating synchronously by chat will yield the same amounts of mutual understanding as negotiating face-to-face.

H2: Negotiating synchronously by chat will lead to the same level of mutual trust as negotiating face-to-face

H3: The number of reached agreements and the negotiator's satisfaction with the outcome will be equal for negotiations by chat and negotiations performed face-to-face.

2 Methodology

2.1 Participants

Thirty-nine people (18 male and 21 female) participated in the study. All participants were communication students from Tilburg University who received a credit point in exchange for their participation. The ages ranged from 18 to 25 with an average of 21.1 (SD = 2.36). The participants were randomly assigned to either the FtF negotiation (N = 19) or the online negotiation (N = 20).

Participants negotiated with a confederate, in both the online and the FtF negotiation. The four confederates (2 male and 2 female) prepared for their role by reading the case, and were instructed to behave as naturally as possible yet very engaged in the negotiation.

2.2 Material

For the experiment a 2,5 page long case was used, based on a case developed by professional negotiation trainers. This case describes a personalized chronological story about a neighbors' quarrel between a student representing a student's house and his/her full time working neighbor. The case provides information about the feelings of the protagonists about the conflict, personalized accusations and personalized objectives.

A questionnaire was developed to measure outcome satisfaction, understanding and perceived trust. The outcome of the negotiation was assessed by a yes/no question (successful or not), all other questions consisted of 7-points Likert scales ranging from 'I completely disagree to I completely agree' or 'not at all – very well' as extremes. The questionnaire items can be categorized into five constructs: *Outcome satisfaction*, *Understanding*, *Being Understood*, *Trust* and *Being Trusted*. The latter four are subdivided into constructs before and after negotiation. Cronbach's alpha was high for all constructs, ranging from .74 to .90 (see Table 1).

2.3 Procedure

The FtF negotiations took place at a small conference room and the chat negotiations in the laboratory facilities, both at the Tilburg University Campus. Upon arrival, the participants were asked to fill in a consent form. Then, they were asked to read the case and to prepare their specific role. In all conditions, the participants played the role of the student. The role of the neighbor was played by a confederate. While reading the case the participant and the confederate were placed in different rooms. During the whole experiment the notion that the confederate was also a participant was upheld. After final instructions, the experiment leader in the FtF condition turned on the camera in order to record the interaction process and left the room. In the online condition the participants were placed into an individual computer cabin and were given the same instructions, including extra instructions about the usage of the interface. After the negotiation, the participants had to indicate the questionnaire on trust and understanding.

Table 1. The reliability of the constructs used as dependent variable (Cronbach's Alpha.

Construct	α	Nr. of items	Example items
Outcome Satisfaction	.76	5	I am satisfied with the outcome
Understanding			
Before negotiation	.74	4	To what extend did you understand the other party?
After negotiation	.79	4	How well did you understand the needs of the other party?
Being Understood			
Before negotiation	.84	3	To what extend did the other party understand you?
After negotiation	.89	3	How well did the other party understand your needs?
Trust			
Before negotiation	.90	3	How well did you trust the other party?
After negotiation	.90	3	To what extend do you think the other party was honest?
Being Trusted			
Before negotiation	.88	3	How well did the other party trust you?
After negotiation	.88	3	To what extent did the other party think you were honest?

3 Results

First, the negotiation outcomes were analyzed. The communication mode had no effect on the outcome; in the FtF negotiations 18 participants said to have reached an agreement versus 17 participants in the online negotiation. In addition, there was no significant difference for *Outcome Satisfaction* ($F(1, 37) = 0.29$, $p = .60$) between the FtF negotiation ($M = 4.79$, $SD = 0.87$) and the online negotiation ($M = 4.65$, $SD = 0.72$). Secondly, to study the effect of the medium on the negotiation process, repeated-measures ANOVA's were conducted for each perception variable as a within subject factor and communication condition as between-factor. A main effect was found for the process: all perception measures were significantly higher after the negotiations (*Understanding the other* $F(1, 37) = 113.56$, $p < .001$, *Being understood* $F(1, 37) = 101.34$, $p < .001$, *Trusting the other* $F(1, 37) = 64.78$, $p < .001$ and *Being Trusted* $F(1, 37) = 84.46$, $p < .001$).

For *Understanding,* an interaction effect was found between medium and process: $F(1,37) = 4.54$, $p < .05$, indicating that the increase was stronger for the FtF negotiations. The same pattern was found for *Being Understood* ($F(1,37) = 7.60$, $p < .01$). The same, however marginally significant, pattern was found for *Trust* ($F(1,37) = 3.19$, $p = .08$). There was no interaction effect found for *Being Trusted*.

Table 2. Trust and Understanding in Negotiation

Constructs	FtF Negotiation (N-dyad= 19) *M* (*SD*)		Online Negotiation (N-dyad = 20) *M* (*SD*)	
	Before	After	Before	After
Understanding	3.49 (1.14)	5.61 (0.50)	3.68 (0.89)	5.09 (0.89)
Being Understood	1.98 (0.84)	4.79 (1.00)	2.60 (0.96)	4.20 (1.23)
Trust	2.56 (1.11)	5.09 (0.64)	2.70 (1.22)	4.31 (1.30)
Being Trusted	2.35 (1.02)	4.86 (1.24)	2.78 (0.99)	4.82 (1.02)

Finally, the post negotiation constructs were compared for both communication conditions by conducting a MANOVA. After the negotiations, the participants in the FtF condition displayed a higher understanding for and trust in the other party than the online negotiators (*Post-Understanding* $F(1, 37) = 5.03$, $p < .05$; *Post-Trust*, $F(1, 37) = 5.54$, $p < .05$) (see Table 2 for means). There was no significant difference between the communication conditions for the other post constructs.

4 Conclusion

The objective of this study was to investigate to what extent the synchronous character of chat communication overcomes the problem in creating mutual understanding and trust between conflicting parties. The first two hypotheses stated that negotiating synchronously by chat yield the same amounts of mutual understanding and the same levels of trust as negotiating FtF. The results show that the feelings of understanding the other party and being understood by the other party increase more in the FtF negotiation than in the online negotiation. In addition, the feelings of trust in the other party are also (marginally) higher after a FtF negotiation than after an online negotiation. However, the results based on the post measurements only show that participants displayed a higher understanding for the other party and a higher trust in the other party after the FtF negotiation, whereas this was not the case in the online negotiation. Thus, the hypotheses are partly confirmed. Negotiators feel equally understood and trusted by the other party in both conditions. However, the own feelings of understanding and trust in the other party increase more after a FtF condition in comparison to the online condition. The third hypothesis stated that the number of reached agreements and the negotiator's satisfaction with the outcome would be equal in both conditions. The results indicate that there is no significant difference in outcome between the conditions. In addition, the negotiators in both conditions feel equally satisfied about the outcome. This confirms the third hypothesis.

These outcomes demonstrate that the synchronous character of chat communication can partly overcome the problems of creating mutual understanding and trust. It can overcome a negotiators belief about the amount of understanding and trust the other party has in him/her but not the feelings of trust and understanding the negotiator has in the other party.

5 Discussion

The present study indicated that as expected, negotiators in chat perform equally well as FtF negotiators, as far as the success rate in terms of agreement and negotiator's satisfaction is concerned. The level of trust and understanding increased in both medium conditions, although this was stronger in the FtF negotiations. However, when the focus is on post negotiation level of the trust and understanding variables, the picture is more nuanced. FtF negotiations still yield higher levels of trust and understanding for the feeling of how well the negotiator understands the counterpart, but interestingly no difference arises for the experience of how well the negotiator was understood and trusted by the other. Building rapport in chat negotiations is therefore equally successful as in FtF-negotiations for the impression you think you make on the other party, but less successful for the impression you have of that counterpart. This differential effect of perspective is intriguing and gives rise to interesting interpretations. It may have to do with the role of non-verbal communication and the impact of the visual impression the counterpart makes. In chat negotiations, the level of trust and understanding the other party evokes is entirely based on the verbal communication as transmitted in the written messages. In FtF negotiations, visual impressions, prosodies and wordings of the message all contribute to the impression the negotiator makes. In other words, the chat negotiator has less cues to convince the other of his trustworthiness and this may well have been at the basis of the lower level of trust in and understanding of the other. Still, apparently the chat medium succeeded in providing enough cues to the participants to give themselves the feeling that they managed to make themselves understood and trusted. This is not only theoretically interesting, since it underlines the importance of perspective in online interaction, but also relevant for analyzing negotiation behavior in online negotiations. The e-negotiator thinks he is trustworthy whereas he is evaluated less positively by his counterpart on this point. This discrepancy could be the source for misunderstanding or at least communicative friction in e-negotiations. Studies that focus on this attribution discrepancy in chat negotiations should shed more light on this question.

The present study was inspired by the findings of Thompson and Nadler [14] that building rapport in e-mail negotiations is difficult. We did not control for this by explicitly studying the same case in an e-mail setting. We managed to show that a chat negotiation approaches a FtF negotiation in the possibilities it offers to build rapport, but including the e-mail condition would have enabled us to show the advantages of synchronous versus asynchronous communication in this respect.

Furthermore, this study of the effect of the medium on negotiations is part of a study where it will be extended with mediations in order to study the question to what extent the presence of a mediator in a conflict interacts with the medium used for communication. Data that explore the rapport building options of chat negotiation in the presence of a mediator are collected at the moment of writing this abstract and will be presented at the conference. We expect a chat mediator to strengthen the rapport building characteristics of chat negotiation.

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PART IV

Collaborative Decision Making

The Role of e-Governance and e-Democracy in Supporting Effective Group Decision Making

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Abstract. In this paper I try to speculate about an importance of ability making group decision effectively for further development of society and role of e-Governance/ e-Democracy in supporting the decision processes in society. Firstly, general advantages of complex network organisms and the role of group decision mechanisms for the building interconnected complex organisms will be explored. Further, the advantages of societies being able to make more effective group decisions in generation of scientific problem-solving knowledge will be discussed. And at last, a convergence between processes of making group decisions in a cognitive democracy society model based on creation of scientific knowledge and e-Government/e-Democracy systems as tools for supporting the making of decision processes will be conducted.

Keywords: group decision making, e-Governance, e-Democracy, cognitive democracy.

1 Introduction

What benefits brings e-Governance for modern society as a tool for supporting group decision making? Initially created to facilitate the administration of government procedures, currently e-Governance and e-Democracy tools converge more and more in numerous platforms for discussion and development of public opinions, being so a basis for making group decisions for society as a whole. A capability of a nation to make group decisions effectively has an inherent influence on success or failure of challenges met on international arena. Thus it is critical to be able to develop effective mechanisms of group decision making, enabling to react promptly and correct for constantly changing environment [1]. This short philosophical survey will contemplate on this topic in frame of cognitive democracy and e-Governance/e-Democracy systems as tools for reaching the set goals.

2 Evolution, complex social organisms and group decisions

What advantages does someone have being in a posse than being alone? How does it come that a lot of complex social organisms have the upper hand in evolutional running races? Obviously, being united into a group is a positive-sum game bringing more resources to group members than they were able to become being single players [2]. The evolution apparently rewards the collective hunt style.

However, in order to build a complex social organism, a set of mechanisms is required in order to make collective group decisions that will regulate relations between "compounds" of social entity – single participants [3]. The evolution exploits the trait of group decision remarkably, enabling e.g. individual cells to form multicellular structures that can again and again join together, building complex, specialized domains that contribute to more complex organisms [4]. The mechanics for group decisions on this level sometimes runs on the "pure hardware" – cells that are physically joined in superorganism use physical semiochemical messages. On the other hand evolution has also created methods for building superorganisms that use the algorithms of making the group decision more on kind of "software" basis – e.g. the collective hunt of cro-magnons consisting of separate members was made on the consensus – i.e. group decision – about how the hunt has to be realized [5]. Group decisions in this case have incorporated simplified models of environment - for example trying to predict the behavior of the prey and then to develop a model of behavior of hunter's pack that was necessary to catch a prey [6].

What was important is to come to a common consensus – to make a group decision – in order to allow successful group hunting. The group decision "mechanics" were thus "wired" in brains of human species and also expressed in language skills and ability to understand and communicate complex abstract models, representing the mix of "hardware" and "software". But after all the evolution was "blind" and its developed group decision mechanisms were designed for special purposes in special niches that were advantageous in our past surroundings but not necessarily should be advantageous in our present dynamic and constant changing hi-technological multinational society [7]. Finding explanations for intrinsic mechanisms of evolution-shaped group decision algorithms and exploiting their advantages in effective ways as well as minimizing the negative influence of "hard-wired bugs" represent very interesting challenge in the research field of group decisions [8].

3 The role of group decisions mechanisms in generation of scientific problem-solving knowledge

The benefits of effective group decisions of hunters and gatherers tribe can be compared with those of modern societies. A society that is better interconnected and is able to perform effective decisions making will eventually outperform on the long run a society that is worse connected and is not so effective at a decision making.

What is remarkable here is that an interconnectivity of society members can be more important for rational decision making than a pure quantity of members in a society contributing to the choice of rational decision. There are a lot of examples when not numerous but better connected minorities are able to outperform numerous but worse-connected majorities [9]. The coordinated group decision of collective hunters pack has usually more prospects for success than an uncoordinated and chaotic one. It also can help well connected groups to take an upper hand over worse connected groups - just try to remember your school where very-few-but-very-well-united-hooligans in a class were able to terrorize a whole school with much-more-numerous-but-worse-united-usual-pupils. The thing is that group decision mechanisms come on scene when it is necessary to form a posse consisting of separate members and hold them together, coordinating a collective action of the posse [10].

One can say that a hunter-gatherer mentality is taken to modern society without changing its very nature. The difference is that in the past our ancestors has collectively hunted mammoths and now we are collectively "hunting" our modern "prey" – new ideas and innovations for solving our problems now, or simplified we are hunting (i.e. generating) the problem-solving knowledge [11]. A potency of our contemporary society is based on technological progress, on understanding the reality "out of there" and giving explanation models for our problem-solving purposes which bring much more resources than our ancestors could hope to have. But the core of our "posse mentality", our group decision mechanisms "hard-wired" in our brains were not changed so much. At last, what are several decades of industrial revolution comparing with millions of years of darwinistic evolution?

A remarkable feature for this case is the benefit that could be brought be effective group decision capability due to the nature of our modern "prey". The resources (problem-solving knowledge) can be generated exponentially in a so-called singularity-growth manner and an interconnectedness of society members contributing to the growth of knowledge can be more decisive than the population of nation in general. And the more "cognocratic" the society is, the more members of cognitive democratic society contribute to knowledge creation and increase the effects of problem-solving capabilities. It also means that knowledge about how to make a group decisions effectively and all associated benefits can also be more effective in small population countries than in countries with huge population [12]. In a light of recent events there is a growing "phobia" in European countries before high populated neighbours like China or India. One of the messages that I want to communicate in this paper is that there is a solution to take an upper hand and to withstand on the box ring with heavy-weighted partner. The solution is that our less populated European society has to be better interconnected for making group decisions more effectively and to generate scientific knowledge more promptly than our political and business rivals, being faster in group decision dynamics, in anticipating properly the behaviour of competitor groups and forestalling them with counter-measures. And a possibility of singularity in nature of knowledge growth does allow it [13].

4 E-Governance as a tool for supporting group decision making

The modern communication tools like internet allow us in some kind to "externalize" our brains and nerve system, enabling us to exchange and expand our ideas, exposing new hypothesis to criticism and improving our ability of knowledge generation. A special avatar of those communication systems called "e-Government" or "e-Democracy" is also a part of complex puzzle map capacitating the modern society to perform group decisions, providing a data interchange infrastructure between society members and institutions [14]. What is the main point of possibilities provided with e-Government and e-Democracy tools? As mentioned before the main important resource of modern society is the generation of scientific knowledge where conjecture and criticism are important factors of making rational explanations for phenomena. The knowledge about how to make a group decision in society effectively is also not an exception and every time when we are ready to make a next "experiment" in our society we make a group decision – e.g. for an acceptance of a new law or an absolution of an old one [15]. How can we be sure that our group decision in this case will be effective, that our decision will minimize the negative effects and maximize benefits for the society as a whole? The principles here are not too much different from those ones used to explain a new scientific hypothesis: we have to expose our "hypothesis" – e.g. our new legislative project - to maximum of criticism that will give explanations which benefits and costs will this or that law bring to different interest groups [16]. And this will be the basis for making the next group decision in out legislation [17].

So how can we maximize the exposure of new law project to the criticism, how can we collect as much opinions as possible from different society members in order to evaluate the benefits and the costs? It can be made through the exposure it to our "externalized" brain and nerve system via different e-Governance and e-Democracy platforms [18]. These tools allow the participation of every single "cell" of the society, collecting the information and helping to deliver the feedback from every corner of complex multicellular organism – our society – in order to make coming group decision as effective as possible for all members [19].

Yes, these mechanisms are just beginning to emerge but the very principles are yet stay the same: exposure the "decision project" to "collective intelligence" and collecting the critical feedback for improving the group decision making.

5 Conclusion

For the conclusion it would be worth to mention that no matter how complex and sophisticated e-Governance and e-Democracy systems would be, the main failure factor will still be behind the systems – a human. While it is obvious that we humans are fallible it is clear that making failure-free decisions (and group decisions especially) at a long term is not possible. But what is important it's to be able to correct mistakes, constantly monitoring the course of events and adjusting our group decisions correspondingly.

In a case if a source of bad group decisions in society cannot be corrected there should be a possibility to eliminate it without violence – for example democratic European political systems make possible an elimination of a bad government via voting system [20]. And it is e-Governance and e-Democracy tools that can allow us to increase the interconnectivity of society members, to express individual opinions publicly, to expose them to criticism and to correct and develop new models of group decision making and support us in creation of a problem-solving knowledge in a cognitive democracy more effectively.

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Participatory Planning for an Environmentally Sustainable City

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Abstract. Chosokabe *et. al.* [1] proposed "Two-stage management model of participatory planning process." The process consists of "the management of the discussion" and "management of planning process." In this study, the proposed model is applied to actual participatory planning process in Japan. The topic of the process was public transportation policy for implementing environmentally sustainable city. Applicability of the proposed model is examined.

Keywords: Participatory Planning Process, Urban Planning, Two-stage Management Model

1 Introduction

In participatory planning process in a community, participant's remarks in the meetings play an important role. The planner tries to understand the participants' concern through their remarks.

On the other hand, participatory planning process should not be a one-way communication process from the participants (citizens) to the planners. The planners should clarify their own opinions/ideas on the corresponding issue. The planners try to present their opinions, and the participants react to such opinions. Whether the participants' reactions are supportive or not, the planner can improve alternatives. Additionally, facilitation by the planners is also needed. The planners need to rephrase the participants' remarks for obtaining understanding of a community. Therefore, participatory planning process is the mutual communicative process between the participants and the planners.

In this study, we call the planner's communication measure in participatory process "the reconstruction of the discussion." The means for the reconstruction of the discussion are, "incorporating participant's idea into alternatives" "rephrasing" and "proposing the planner's idea."

Chosokabe *et. al.* [1] proposed "Two-stage management model of participatory planning process." The process consists of "the management of the discussion" and "management of planning process." In this study, the proposed model is applied to the actual participatory planning process in Japan. The topic of the process was public transportation policy for implementing an environmentally sustainable city.

Applicability of the proposed model is examined. Especially, the actual methodologies for the reconstruction of the discussion are focused on.

2 Management of Participatory Planning Process

Fig. 1 shows the two-stage management model of participatory planning process proposed by Chosokabe *et. al.* [1]. This management model defines two types of subjects, "participants" and "planners." The participants are citizens or stakeholders who are involved in the participatory planning process. The planners manage the participatory planning process, and obtain alternatives. Typical examples of the planners are government officials, consulting engineers, and non-governmental organizations. The management model regards participatory planning process as mutual communication process between the participants and the planners.

The management model includes two types of managements, "Management of Planning Process" and "Management of the discussion." "Management of the discussion" is facilitation of dialogues within each the discussion. "Management of Planning Process" is the management for adopting the participants' opinions/ideas into alternatives effectively. In this study, we focus on "Management of Planning Process."

As shown in **Fig. 1**, "Management of Planning Process" consists of four phases. The details of these phases are as follows.

Phase 1: The Initial Hypothesis Setting

The planners have their original viewpoints on the corresponding issue. Without the original viewpoints, the planners cannot make alternatives. However, if the planners are not conscious of their own viewpoints, some problems can be caused in participatory planning process. First, such viewpoints may function as bias for the participants' opinions. The planners may exclude opinions which are far from their viewpoints unconsciously. Secondly, when the participants concentrate into the specific topics in the discussion, the planners need to present a broader framework. Such a framework is based on the planners' original viewpoints. If the planners do not recognize their own viewpoints, they may be trifled by the participants' discussion.

For avoiding such troubles and realizing mutual communication between the participants and the planners, the planners should clarify their own viewpoints in advance of meetings. In this model, such opinions/idea of the planners are called "initial hypothesis."

Phase 2: 1st Discussion

After setting initial hypothesis, the planners held a meeting. During the discussion, the planners may find recognition gaps between the participants and themselves. One of the usefulness of the 1st discussion is such actualization of recognition gaps. Since the participants have their own knowledge/experiences, they tend to have different viewpoints from the planner's initial hypothesis. Existence of the participants' original viewpoints is the main reason of introducing participatory planning process.

Phase 3: The Reconstruction of the Discussion

The planner should incorporate the participants' original opinions/ideas into the alternative. On the other hand, even if the participants do not mention, some factor may be important. The planner should try to introduce some perspectives which the participants don't have but are important. Concrete methodologies of the reconstruction are as follows.

- Incorporating participant's idea into alternatives
- Rephrasing
- Proposing the planner's viewpoints

Phase 4: 2nd Discussion

After the discussion is reconstructed, the discussion by the participants is restarted. If consensus is reached, the planners make alternatives and final decision is made. If consensus is not reached, the discussion is reconstructed repeatedly (**Fig.1**).

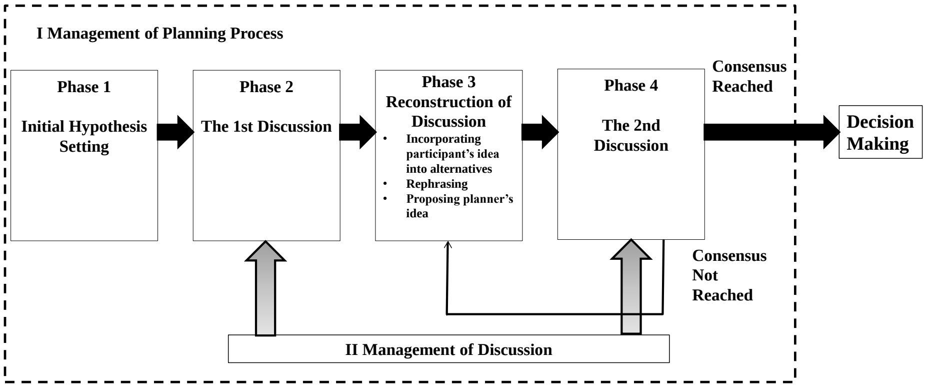

Fig. 1 Two-stage management model of participatory planning process

3 Application of the model to actual participatory planning process

3.1 Outline of the process

In this chapter, the two-stage management model is applied to the actual participatory planning process. The name of the process is "Committee for Public Transportation Policy in Ube City." The committee was set up by Ube city in Japan. The main topics of the committee were as follows [2].

- For realizing an environmentally sustainable city, public transportation is regarded as one of principal means. For that purpose, direction of public transportation policy is discussed in this committee.
- For adapting to aging and population-decreasing society, policy for realizing efficient public transportation network is discussed.

Six meetings were hold from March, 2013 to December, 2013. The member of the committee (the participants) were, community leaders, representatives from public transportation companies (bus, railway and taxi), a care manager, a high school teacher, representatives from industries and merchants, university professors and a student. Contents of each meeting were as follows.

- The 1st meeting: Orientation
- The 2nd and the 3rd meetings: Group discussion
- The 4th and the 5th meetings: The discussions for the final proposal
- The 6th meeting: conclusion

Final proposal was submitted to the mayor of Ube city in January, 2014.
Authors were involved in the process as the members of the planners.

3.2 Application of the two-stage management model

Application of two-stage management model is described according to Chapter 2.

Phase 1: The Initial Hypothesis Setting
As initial hypothesis, the planners set up the following seventeen viewpoints.
(Viewpoint on relationship between urban planning and public transportation)
1. Relationship between urban planning and public transportation
2. Direction for realizing compact city
3. Urban axis

(Viewpoint on bus transportation)
4. Roles of bus transportation
5. Ube city's principle for financial support for bus transportation
6. Business model of public enterprise for bus transportation
7. Subsidy for elderly and disabled people
8. Bus network
9. Facilities for bus transportation
10. Ideas for improving bus transportation

(Viewpoint on railway transportation)
11. Roles of railway transportation
12. Relationship between bus and railway
13. Roles of railway stations in a city
14. Ideas for improving railway transportation

(Viewpoint on small-scale public transportation)
15. Public transportation policy in mountainous area
16. Ideas for improving on demand transportation service
17. Activation of on demand transportation service

Phase 2: The 1st Discussion
In the 2nd and the 3rd meetings, the participants were assigned into the three groups. Then each group discussed freely about the problem on public transportation. The 2nd and the 3rd meetings can be regarded as the 1st discussion in **Fig.1**.
Authors summarized the participants' opinions, and sorted into the categories according to the seventeen viewpoints which were set up as initial hypothesis. **Fig.2** shows the number of the participants' opinions for each viewpoint.
In summarizing the participants' opinions, many opinions which cannot be sorted into above seventeen viewpoints were found. Within such opinions, the most frequently mentioned opinions were related to commuting transportation for high school students. Especially in group A (**Fig.2**), the many participants mentioned about the high school students. By setting initial hypothesis (viewpoints from 1 to 17) in advance, the planners can perceive recognition gap between themselves and the participants.

Before the 1st discussion, the planners had concern about the use of public transportation by elderly and disabled people (the viewpoint 7). However, high school students also have mobility problem, because they cannot drive a car by themselves and they have to depend on public transportation. Acquisition of the viewpoint on commuting transportation for high school students suggests effectiveness of participatory planning process and introduction of initial hypothesis. In **Fig.2**, the new viewpoint on "high school students (the viewpoint 18)" is introduced.

On the other hand, no participants mentioned about urban axis (the viewpoint 3) and facilities for bus transportation (the viewpoint 9). Although the participants mentioned about urban planning (the viewpoint 1), they did not mention about the concrete urban structure. Similarly, while they discussed financial support for elderly and disabled people (the viewpoint 7), no remark was made on facilities for such people. If initial hypothesis was not set up, the planner may not find the lack of mentions on these topics. Perception of unmentioned topics is another effectiveness of introducing the initial hypothesis.

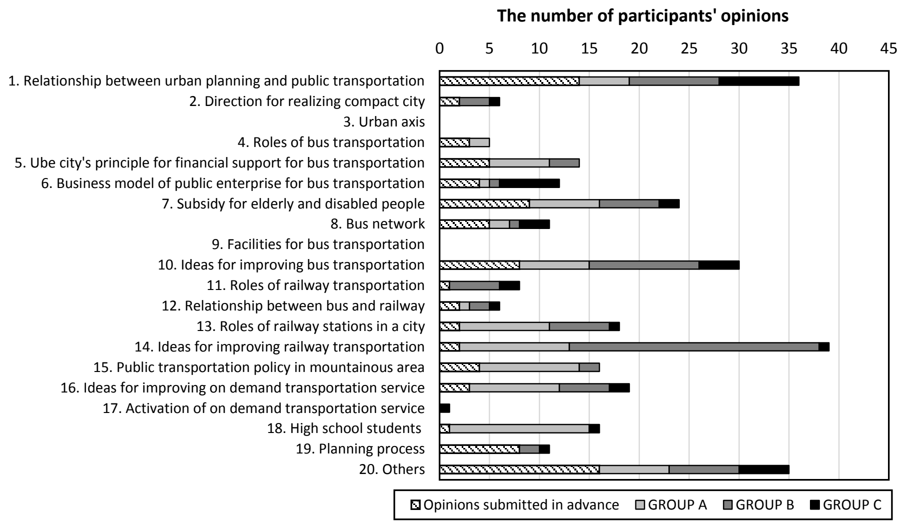

Fig. 2 The number of the participants' opinions for each viewpoint

Phase 3: The Reconstruction of the Discussion

After the 1st discussion (the 2nd and the 3rd meetings), the planners analyzed participants' opinions and found the above mentioned recognition gaps. When the planners prepared for the 4th and the 5th meetings, they tried to reconstruct the discussion. In this case, "Incorporating participant's idea into alternatives" and "Proposing the planner's viewpoints" were tried. The details are as follows.

"*Incorporating participant's idea into alternatives*": As mentioned in phase 2, participants mentioned about commuting transportation for high school students. The planners decided to adopt to incorporate this viewpoint into the final proposal, and adding description about transportation for students in the draft of the final proposal. The draft was submitted to the 4th meeting.

"*Proposing the planner's viewpoints*": No participants mentioned about urban axis (the viewpoint 3) and the facilities for bus transportation (the viewpoint 9). The planners prepared the documents for explaining about the concept of urban axis and the importance of facilities for improving mobility of elderly and disabled people (low-floor bus etc.). The document was delivered and explained in the 5th meeting.

Phase 4: **The 2nd Discussion**

The 4th and the 5th meeting can be regarded as the 2nd discussion in **Fig.1**. Introduction of the viewpoint on high school students was approved by the participants.

In the 2nd discussion, three participants mentioned "low-floor bus." Two participants mentioned "a wheel chair," and other two participants mentioned "a guide dog." These words were not mentioned in the 1st discussion (the 2nd and 3rd meetings). This result suggests that mobility of elderly and disabled people had become the participants' concern. Consequently, "proposing the planner's viewpoints" functioned for the viewpoint.

As for the urban axis, one participant newly mentioned "urban axis," but other participants didn't. Comparing with the mobility of the elderly and the disabled people, the urban axis was not recognized as a concern even after the reconstruction of the discussion.

4 Conclusion

In this study, the two-stage management model for participatory planning is applied to the actual planning process in Japan. The topic of the process was public transportation policy for implementing an environmentally sustainable city. As initial hypothesis, the planners set up the seventeen viewpoints. By setting initial hypothesis in advance, the planners can perceive recognition gap between themselves and the participants. Acquisition of the participants' viewpoints and perception of unmentioned topics are effectiveness of participatory planning process and introduction of initial hypothesis. "Proposing the planner's viewpoints" functioned, because some participants mentioned related words only after the reconstruction of the discussion.

This study focused only on the process for identifying the set of alternatives. The participatory planning discussed in this study can be applied to identify the decision criteria for decision making in a community. This will be the subject of future study.

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PART V

Decision Support Systems

Multiple Participant Models of Urban Infrastructure Performance and Decision Support

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Abstract. Representations of an infrastructure network model and its state space equations are presented to analyze resilience of a system over time. A simplified example is utilized to demonstrate application of these methods. Connecting these models to agent-based conflict models to generate scenarios for decision support is discussed.

Keywords: Graph Models; Multiple Participants; State Space; Urban Infrastructure Resilience.

1 Introduction

Urban infrastructure systems are composed of networks of facilities and services that underlie the functions of cities. A facility such as a water treatment plant or power substation is an infrastructure system within an infrastructure system. Moreover, infrastructure systems including water management infrastructure or energy infrastructure are also part of a larger network of dependencies [15]. This larger network of dependencies consists of other infrastructure, users, operators, and other socio-economic, political and environmental interconnections. Informed decision making within this web of complex interactions among systems and participants within these systems requires understanding of this larger context, as well as, how this context changes over time. In the short-term, for example, the event of a natural hazard changes the operating conditions of a system. In the extreme case, infrastructure systems are pushed to their design limits and beyond, as happened to the levees and flood walls of New Orleans during Hurricane Katrina [13]. Over longer timescales, for example, the complexity of systems increase as more connections are created among its components [14], which can amplify expected events to unexpected proportions, such as the 2003 Northeast blackout affecting at least 50 million people [1][17]. Due to the high capital investments needed to maintain and revitalize infrastructure, strategic planning is required of our political leaders and managers of urban infrastructure [16]. In strategic planning, participants recognize the mission of decision making processes within a vision, how the decision context may change, and hence consider variable options for achieving their goals under a changing context.

The objective of this paper is to present multiple participant decision making models for strategic infrastructure planning using a combined complex adaptive systems and conflict resolution approach, which was presented at GDN2013 [4]. Based on the socio-ecological framework to study evolution of cities and their resilience in [4], adaptive cycles conceptualize the resilience context of an urban infrastructure system, while conflict models describe the strategic context of participants involved in and affected by infrastructure management decisions. The purpose of this paper is to further operationalize the approach in order to inform decision making within a strategic planning construct. To this end, network models and state space equations are formulated to analyze resilience of a system over time. These functional models are then integrated with agent-based models to synthesize interactions among participants to generate scenarios for decision making.

In Section 2, representations of a network model and its state space equations are presented. A simplified example is utilized to demonstrate application of these methods. Connecting these models to agent-based conflict models to generate scenarios for decision support is discussed in Section 3. Finally, Section 4 concludes this paper with future work on developing decision support tools for disaster response on one hand, and urban energy resilience and sustainability on the other.

2 Infrastructure networks and state space equations

Infrastructure is built for a purpose and in order to fulfill that purpose it relies upon external influences and support to continue [11]. A coal fired generating plant, for example, depends on the freight industry for delivery of coal; the freight industry depends on well-maintained roads to transport physical goods; roads depend on storm water drains or storm sewers to clear away precipitation, as well as electric power to regulate traffic flow with traffic control signals; electric power distributors depend on coal fired generating plants, as well as nuclear, gas, hydro and wind power plants. Conversely, energy suppliers depend on energy consumers; the construction and maintenance of roads depend on drivers to use the roads; and storm sewers depend on precipitation to justify their capacity.

In a network model, nodes represent infrastructure facilities and services, as well as resource-bases and end-uses which are defined by boundaries of the overall modelled system. Arcs represent dependencies. A 'directed edge' (denoted by an arc with an arrow) *into* node i represents a dependency, which means that node i requires a flow of resources or information from the upstream node. An arc *out of* node i means that node i can impact the downstream node directly and any other downstream node indirectly. End-uses are considered external to the system model boundary and delineate the consequences that decision makers consider important. Resource-bases are also considered external to the modelled system. The infrastructure network is

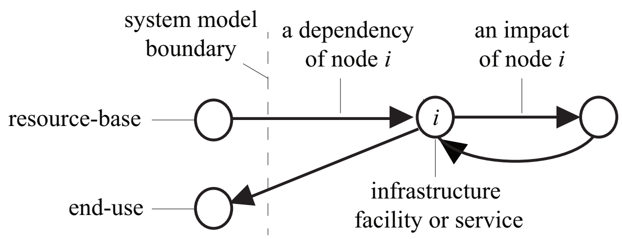

Fig. 1. Network model of dependencies and impacts of an infrastructure component

thus described as an open system. Fig. 1 illustrates the basic components of a network model of urban infrastructure.

The operation of networks of interdependent infrastructure involves many measures of operation. The dynamics of each node's measures dictate not only its own recovery after a shock, but also the recovery of the network as a whole as changes propagate along the dependency pathways between nodes. Consider, for the time being a measure called performance, the exact meaning of this measure is intentionally general at this point, but it can be assumed to mean financial performance, or the capability of a plant. As Fig. 2 illustrates, this recovery of performance can take many forms following an event.

In the first case (a) Steady recovery is a typical performance curve that many operators aim for when devising their resilience plans. The middle case, (b) Failed recovery, is a near-worst case scenario whereby the recovery to past performance never occurs. This may happen if the devastation is so great or the response so poor that recovery becomes impossible. Finally, in (c) Overshoot recovery, a quick return to high levels of performance is achieved that even for a time overshoot previous levels. At first glance, this seems like a positive scenario, yet a network-wide result of such recovery is not necessarily positive if it induces conflict among nodes due to

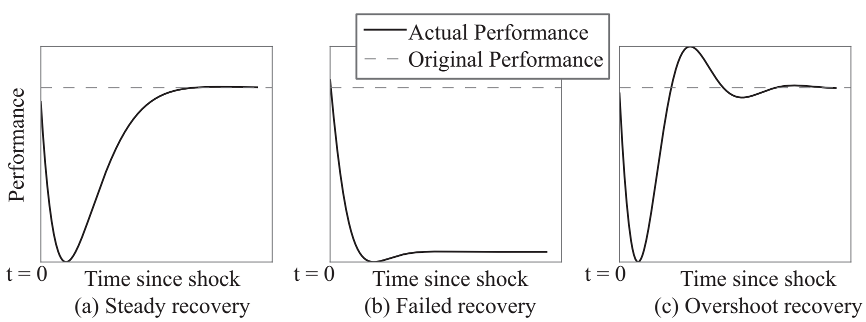

Fig. 2. Selected varieties of node response to a disturbance or shock over time (t = 0 corresponds to the time of the shock).

limited resources. If a given node's recovery needs are so great as to rob other nodes of key resources, then chains of dependency can propagate performance deficiencies [12]. Such a situation is increasingly likely if there are a number of nodes whose recovery overshoots what is actually required of them from a network-wide perspective. The recovery of all of the nodes, ideally, is synchronized to reduce network-wide down time and losses. Whether recovery takes the form of cases (a), (b) or (c) establishes a large portion of the context under which group decision making and negotiation must occur among stakeholders and operators of different nodes.

Since the complex dynamics among nodes relate strongly to the dynamics of each node, dependency representations must capture node dynamics. This requires characterizing the relationship among the inputs and outputs of a node as well as the state of the node [10]. Following, a state space representation is proposed to model a focal node in a dependency network. The purpose of the state space model is to capture the interrelationships among inputs, outputs and node state. A short example then illustrates the usefulness of this approach for specifying the impact of shocks on dependency networks, and where the leverage points are for making decisions to alter these impacts to increase the resilience of a city.

2.1 Network and state space representation

The network of infrastructure dependencies can be represented as a graph comprised of vertices (nodes) $\mathbf{v} = \{1 \quad \ldots \quad N\}$ and directed edges (or arcs) $\mathbf{E} = \{(i, j) \mid i, j \in \mathbf{v}\}$. An arc (i, j), where node i is the source node and node j is the destination node, has an associated vector $\mathbf{d}_{i,j}$ of length q_i, the number of output measures of node i, comprised of zeros (0) and ones (1) indicating whether a given output of node i is an input to node j. Hence, $\mathbf{d}_{i,j}$ indicates the dependencies of node j on node i, or conversely the impacts of node i on node j.

A discrete state space representation of node $i \in \{1 \ldots N\}$ is proposed as follows[1]:

$$\mathbf{x}^i_{t+1} = \mathbf{A}^i \mathbf{x}^i_t + \mathbf{B}^i \mathbf{z}^i_t + \mathbf{\Gamma}^i \mathbf{h}^i_t \tag{1}$$

$$\mathbf{y}^i_t = \mathbf{\Lambda}^i \mathbf{x}^i_t + \Phi^i \mathbf{z}^i_t + \Theta^i \mathbf{h}^i_t \tag{2}$$

where the focal node is identified as node i and t is the current time step. In the following explanation of Equations 1 and 2, the superscript i and subscript t are implied. The state of the focal node is described by $\mathbf{x}$, which is a $n_i \times 1$ vector where n_i is the number of state variables of node i. As t increases, the state variables are updated. A $n_i \times n_i$ state transition matrix $\mathbf{A}$ feeds the current state into the new state $\mathbf{x}_{t+1}$. The new state is also affected by the change in the performance of node i's

[1] Assuming the typical simplification of considering differentials in a linear regime of the state space [18].

dependencies denoted by $\mathbf{z}$ (a $m_i \times 1$ vector where m_i is the number of output measures from other nodes $j \neq i$ that are directed into node i)[2] and the change in the realized hazard levels on node i, which are represented by $\mathbf{h}$ (a $r \times 1$ vector where r is the number of hazards). Hazards, as well as dependencies, can induce stress or shock on node i. As hazards are considered independent variables, a stress caused by a hazard would be modelled with a ramp function that approaches a certain threat boundary, whereas a shock due to a hazard would be captured with an impulse or step function that exceeds the threat boundary. How dependencies and realized hazards impact the focal node's state is described by $\mathbf{B}$ a $n_i \times m_i$ matrix and $\mathbf{\Gamma}$ a $n_i \times r$ matrix, respectively. The current state of the focal node will in turn influence the node's outputs. The change in the performance of the outputs of node i that serve as dependencies to other nodes $j \neq i$ is represented by $\mathbf{y}$, a $q_i \times 1$ vector where q_i is the number of outputs of node i; $\mathbf{\Lambda}$ is a $q_i \times n_i$ matrix describing the impacts of node i's state on its outputs. The focal node's outputs may also be directly affected by changes in the performance of its dependencies and realized hazard levels if the node anticipates changes. If a decision maker can forecast changes in dependencies and hazard levels based on current data, then the outputs of an infrastructure system can be influenced in advance through feed-forward compensation. This capability is modelled by $\mathbf{\Phi}$, a $q_i \times m_i$ matrix describing the influence of the current performance of the focal node's dependencies on its own outputs, and $\mathbf{\Theta}$, a $q_i \times r$ matrix describing the influence of the current hazard levels on the outputs of node i.

2.2 Example implementation of network and state space representation

An example network and state space representation of a simplified real-world infrastructure dependency is presented. A partial dependency network is illustrated in Fig. 3, in which a natural gas power plant is the system-of-interest. This sample is useful for illustrating the interplay among different nodes under the realization of a particular hazard, namely a heat wave. Using node *1* as the focal node, a state space representation is demonstrated in practice considering the impact of a heat wave on the performance of the natural gas power plant.

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[2] The matrix $\mathbf{z}_t^i$ is a concatenation of all of the outputs of all other nodes $j \neq i$ that are dependencies of node i. Mathematically it is the concatenation of $\mathbf{y}_t^j$ for all $(j,i) \in \mathbf{E}$ where $d_{j,i} = 1$ for all $d_{j,i} \in \mathbf{d}_{j,i}$.

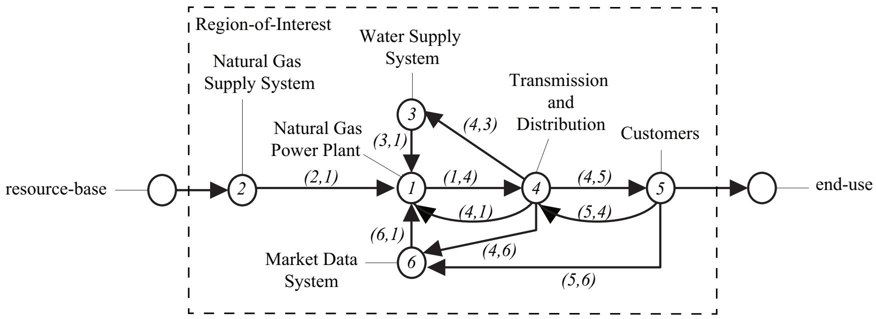

Fig. 3. Partial dependency network of infrastructure systems.

To simplify the demonstration, it is assumed in this case that there is only one dependency per arc ($\mathbf{d}_{i,j}$ has only one non-zero entry) and that the state transition matrix ($\mathbf{A}$) and the impact matrices ($\mathbf{B}$, $\mathbf{\Gamma}$, $\mathbf{\Lambda}$, $\mathbf{\Phi}$, $\mathbf{\Theta}$) are assumed to be invariant over the relevant timescale provided that there are no interventions on the part of decision makers. A qualitative version of the state space equations for this scenario is shown in Equations 3 and 4. In this particular case, depending on the impact factors and heat wave hazard level, the power plant may simply be able to respond by raising power output to meet customer demand. It may also be the case that the hazard level is sufficiently high and the impact matrices are exceedingly imposing that the change in power plant capacity is limited; hence the plant cannot respond adequately.

$$
\begin{aligned}
&\underbrace{\left[\text{New departure from nominal max capacity}, x_{t+1}^{1}\right]}_{\mathbf{x}_{t+1}^{1}} = \\
&\quad \underbrace{\left[\alpha_1\right]}_{\mathbf{A}^1}\underbrace{\left[\text{Current departure from nominal max capacity}, x_t^{1}\right]}_{\mathbf{x}_t^{1}} + \\
&\quad \underbrace{\begin{bmatrix} \beta_1 \\ -\beta_2 \\ \beta_3 \\ \beta_4 \end{bmatrix}^T}_{(\mathbf{B}^1)^T} \underbrace{\begin{bmatrix} \text{No change in pressure of natural gas supply} \\ \text{Increase in temperature of water supply} \\ \text{Demand increase reported by data node} \\ \text{Capacity remains on transmission and distribution} \end{bmatrix}}_{\mathbf{z}_t^{1}} + \qquad \qquad (\mathbf{3}) \\
&\quad \underbrace{\begin{bmatrix} \gamma_1 \\ \gamma_2 \end{bmatrix}^T}_{(\mathbf{\Gamma}^1)^T} \underbrace{\begin{bmatrix} \text{Increase in temperature} \\ \text{Increase in humidity} \end{bmatrix}}_{\mathbf{h}_t^{1}}
\end{aligned}
$$

$$
\underbrace{\left[\text{Power output, } y_t^1\right]}_{\mathbf{y}_t^1} =
$$

$$
\underbrace{\left[\lambda_1\right]}_{\boldsymbol{\Lambda}^1}\underbrace{\left[\text{Current departure from nominal max capacity, } x_t^1\right]}_{\mathbf{x}_t^1} +
$$

$$
\underbrace{\begin{bmatrix} \varphi_1 \\ -\varphi_2 \\ \varphi_3 \\ \varphi_4 \end{bmatrix}^T}_{(\boldsymbol{\Phi}^1)^T} \underbrace{\begin{bmatrix} \text{No change in pressure of natural gas supply} \\ \text{Increase in temperature of water supply} \\ \text{Demand increase reported by data node} \\ \text{Capacity remains on transmission and distribution} \end{bmatrix}}_{\mathbf{z}_t^1} + \qquad \textbf{(4)}
$$

$$
\underbrace{\begin{bmatrix} -\theta_1 \\ -\theta_2 \end{bmatrix}^T}_{(\boldsymbol{\Theta}^1)^T} \underbrace{\begin{bmatrix} \text{Increase in temperature} \\ \text{Increase in humidity} \end{bmatrix}}_{\mathbf{h}_t^1}
$$

The impact matrices, while assumed to be constant under no intervention, are in fact dependent upon decision making processes. For example, through interventions of preparedness, risk mitigation strategies or building of resilience the impact matrices are influenced. The modifications of impact matrices change the impacts of dependency failures and realized hazards, as well as the outputs to other nodes. Decision makers need to account for contextual influences such as the risk context in terms of risk perceptions of various participants, the broader resilience context in terms of the adaptive cycle of the network as a whole, the strategic context of conflicting as well as complementary value systems and objectives of all decision makers, and constraints imposed by the institutional (socio-economic-political) and technological environments.

3 Agent based models for decision support

An agent-based modelling framework may be used to situate a network model and its associated state space representations of nodes within the context of decision making processes. As argued in the previous section, the interplay among nodes defines the responses of nodes and thus the behaviour of the overall system. Due to conflicts among the values and preferences of the stakeholders of separate nodes, individual goals may clash with the achievement of system-wide resilience. Such can be the case with private-sector power plant owners, for example, whose primary responsibility of business is to maximize profits and elected government representatives whose main desire is to garner political support in their own constituencies. Interactive decision support with the Graph Model for Conflict Resolution (GMCR) [7–9] can help stakeholders take into account their own goals, options and preferences along with the goals, options and preferences of other participants to determine potential cooperative outcomes that would not be reached if participants pursued individual goals on their own. It is also suggested that state space models of risk perceptions and GMCR conflict models of risk management may be connected to incorporate strategic considerations into risk analysis [6]. Moreover, with an agent-based framework to model competitive and cooperative behaviour [3, 5], conflict dynamics can be modelled to project ensembles of potential conflict evolutions which illuminate possible pathways to desired joint outcomes. A decision support system that connects network models and state space representations with agent-based models of conflict dynamics that take into account changing contextual variables would provide participants with a tool to develop and effectively analyze a multitude of scenarios to construct and negotiate contingency plans for desired levels preparedness and response capability of urban infrastructure systems.

4 Future Work

The next goal of this research is to develop a disaster response decision support system for city emergency response in a catastrophe. On the other hand, resilience is but one objective. Other goals, such as sustainability are of similar interest to many urban decision makers and stakeholders. Urban energy networks [2], and other varieties of urban networks could be incorporated into the agent based conflict dynamics model along with the urban dependency network. Similarly, the goal is to provide decision support in multi-objective, multi-participant strategic planning for resilience and sustainability of cities.

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Supplier selection using Interpolative Boolean algebra and TOPSIS method

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Abstract. Selection of the most suitable supplier is a strategic decision that ensures profitability and long-term existence of a company. This process is essentially reducible to the problem of multi-attribute decision-making method. The large number of quantitative and qualitative attributes is considered. This paper presents a model of supplier selection in the telecommunication company. Weighted approach for solving this model was used combined with logical interactions between attributes. Setting logical conditions between attributes was carried out by using the Boolean Interpolative Algebra. Then the logical conditions are transformed into generalized Boolean polynomial that is through logical aggregation translated into a single value. Finally, the ranking of the suppliers is provided by using the Technique for Order Performance by Similarity to Ideal Solution. Using proposed model decision makers will be able to clearly express their demands through logical conditions, which allows them to conduct a comprehensive analysis of the problem.

Keywords: Fuzzy logic · Interpolative Boolean algebra · Generalized Boolean polynomial · Logical aggregation · Technique for Order Performance by Similarity to Ideal Solution · Supplier selection problem.

1 Introduction

The sector of telecommunications develops rapidly on a daily basis, and under such conditions companies must choose quality suppliers in order to stay competitive on the market. In real situations, decision makers often want to set up mutual relationships between the attributes in order to bring the best possible decision. As conventional fuzzy methods of multi-attribute decision-making do not allow setting of logical interactions between attributes, i.e. they are not in the Boolean frame, the consistent fuzzy logic is introduced. The aim of this study is to develop a practical tool for mapping linguistic requirements of decision makers with an appropriate Boolean polynomial. The basis of proposed approach is interpolative realization of Boolean algebra that transforms logical conditions between attributes into a generalized Boolean polynomial, then merges logical conditions into a single value by using a logic aggregation function. Finally, the ranking of the suppliers is provided using the Technique for Order Performance by Similarity to Ideal Solution.

The paper is structured as follows: in Section 2 an introduction of Boolean consistent fuzzy logic is given. Section 3 explains steps of TOPSIS method. Section 4 analyzes the problem of selecting suppliers by using Boolean consistent fuzzy logic and TOPSIS. Finally, the paper concludes with Section 5.

2 Boolean consistent fuzzy logic

Fuzzy logic was introduced by Zadeh [1] as an efficient way to mathematically represent uncertain and imprecise human assessments. The main advantage of fuzzy logic is that it is generalization of classical (binary) logic and does not require completely exact data, elements can take values from the interval [0,1]. However, the main disadvantage of fuzzy logic is that it is not in the Boolean frame.

Extension of fuzzy logic by introducing logical interactions is enabled by using Interpolative Boolean Algebra - IBA [2,3], which is a consistent generalization of fuzzy logic. IBA is a real valued, and/or, [0,1] value realization of Boolean algebra [4]. Under the IBA all Boolean axioms and theorems apply. IBA has two levels – symbolic and valued.

On symbolic level one of the basic concepts is the structure of IBA elements. The principle of structural functionality indicates that the structure of any element of IBA may be directly calculated based on the structure of its components. The structure is an independent value and that is the key to preserving Boolean laws both at the symbolic and at the level of values [5]. This principle treats negation differently and that allows preservation of the excluded middle ($a \vee \neg a = 1$) which is not respected in the conventional fuzzy logic [6].

On a valued level the values are introduced in this way to preserve all the laws set symbolically, in the general case it is a matter of interpolation [7,8]. Elements take values from an interval and suitable operator for generalized product is chosen [9].

2.1 Generalized Boolean polynomial and logical aggregation

IBA is technically based on generalized Boolean polynomial (GBP) [8]. That means if any element of Boolean algebra can be represented in a canonical disjunction way, it can be represented also by appropriate GBP. And thus, it allows for the processing of the corresponding element of Boolean algebra into the value on the real interval [0,1] using operators such as classical (+), classical (-) and generalized product ($\otimes$) [9]. The generalized product (GP) is a subclass of the conventional fuzzy T norm satisfying the non-negativity axiom [7].

Within the IBA, the method enabling unification of factors is referred to as Logical Aggregation (LA). The main task of LA is the fusion of the primary attributes into one globally representative value using logical function. A Boolean logical function enables the aggregation of factors, i.e. it is an expression that transforms into GBP.

3 TOPSIS method (Technique for Order Performance by Similarity to Ideal Solution)

TOPSIS represents a classical multi-criteria decision-making method. This method ranks alternatives according to their distance from the Positive ideal solution (PIS) and Negative ideal solution (NIS). The ranking of alternatives is based on the relative similarity to the ideal solution, which avoids the situation of the alternative having the same similarity to both PIS and NIS. The TOPSIS methodology presented by Hwang and Yoon [11] consists of the following steps:

Step 1,2: The decision matrix is normalized and weighted.

Step 3: PIS and NIS are determined by **Eq. (1,2)**:

$$A^* = \{V_1^*, V_2^*, \dots, V_n^*\}, \tag{1}$$

$$A^- = \{V_1^-, V_2^-, \dots, V_n^-\} \tag{2}$$

Step 4: The distance of each alternative from PIS and NIS is calculated by **Eq. (3,4)**:

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(V_{ij} - V_j^-\right)^2},\ j = 1,2,\dots,J \tag{3}$$

$$d_i^* = \sqrt{\sum_{j=1}^{n}\left(V_{ij} - V_j^*\right)^2}, j = 1,2,\dots,J \tag{4}$$

Step 5: The closeness coefficient for each alternative (CC_i) is calculated by **Eq. (5)**:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-} \tag{5}$$

***Step* 6**: At the end of the analysis, the ranking of alternatives is made possible by comparing the CC_i values.

4 The method of solving the problem of supplier selection by using IBA and TOPSIS

A real-life company specialized in installation and maintenance of telecommunications systems wants to select the most suitable supplier that would deliver distributed antenna systems. Three suppliers were considered that are ranked based on four basic attributes and eleven sub-attributes (**Table 1**).

Table 1. Presentation of attributes and sub-attributes

Attributes	Sub-attributes	Attribute type	Unit	Max/Min
Product performance (K_1)	Technical features (k_{11})	Qualitative	EX, VG, G, ST, US	Max
	Product quality (k_{12})	Qualitative	EX, VG, G, ST, US	Max
	Delivery time (k_{13})	Quantitative	Day	Min
Supplier profile (K_2)	Reference (k_{21})	Qualitative	EX, VG, G, ST, US	Max
	Brand position (k_{22})	Qualitative	EX, VG, G, ST, US	Max
Financial aspect (K_3)	Product price (k_{31})	Quantitative	Eur	Min
	Transport costs (k_{32})	Quantitative	Eur	Min
	Customs and fees (k_{33})	Quantitative	Eur	Min
Support and services (K_4)	Service and maintenance (k_{41})	Qualitative	EX, VG, G, ST, US	Max
	Technical support (k_{42})	Qualitative	EX, VG, G, ST, US	Max
	Training aids (k_{43})	Qualitative	EX, VG, G, ST, US	Max

EX-excellent, VG-very good, G-good, ST-satisfactory, US-unsatisfactory

The quantitative and qualitative values of the sub-attributes are presented in **Table 2**.

Table 2. The values of sub-attributes

	Production performance (K_1)			Supplier profile (K_2)		Financial aspect (K_3)			Support and services (K_4)		
	k_{11}	k_{12}	k_{13}	k_{21}	k_{22}	k_{31}	k_{32}	k_{33}	k_{41}	k_{42}	k_{43}
S_1	VG	G	45	G	ST	387	125	100	EX	EX	US
S_2	ST	VG	45	EX	VG	192	135	120	EX	VG	G
S_3	G	VG	30	G	VG	284	85	110	G	EX	EX

As mentioned above, fuzzy logic takes values from the $[0,1]$ interval. It indicates that it is necessary to convert the value of sub-attributes to interval $[0,1]$, i.e. it is necessary to perform a normalization (**Table 3)**.

Table 3. Normalized values of sub-attributes

	Production performance (K_1)			Supplier profile (K_2)		Financial aspect (K_3)			Support and services (K_4)		
	k_{11}	k_{12}	k_{13}	k_{21}	k_{22}	k_{31}	k_{32}	k_{33}	k_{41}	k_{42}	k_{43}
S_1	0.8	0.6	0.4	0.6	0.4	0.4	0.6	0.8	1	1	0.2
S_2	0.4	0.8	0.4	1	0.8	0.8	0.6	0.6	1	0.8	0.6
S_3	0.6	0.8	0.6	0.6	0.8	0.6	0.8	0.6	0.6	1	1

The Interpolative Boolean algebra does not treat logical expressions in the same way as the conventional fuzzy logic does. In effect, structure and values are separated into two different levels of logic. Contrary to the conventional fuzzy logic, IBA is based on the principle of structural functionality – the structure of any element may be directly calculated based on the structure of its components [5]. In accordance with this principle, negation is treated differently. This allows the preservation of the laws of excluded middle and contradiction [12].

Given that certain attributes may influence or be influenced by other attributes as well as the fact that the importance of the attributes may vary based upon the demonstrated level of other attributes, it is necessary to take this account while choosing the best alternative [4]. In order to bring the best possible decision, in real situations, decision makers often want to set the mutual relationships between the attributes. Therefore, it is proposed that a logical function is used for defining the importance of the attributes with respect to the goal instead of comparison matrices. The logical function, which takes into account the correlation among the attributes should be defined within Boolean frame. In other words, the main goal of Logical Aggregation is to combine the initial attributes into a single global attribute using a logical function as a logical aggregation operator [4]. This was enabled by using the logical conditions, presented hereinafter:

Condition 1: "If the production performances are at a high level, then the product is acceptable, if it is not at satisfactory level then pay attention to the supplier profile, the financial aspect and the support and services." (**Eq. (6)**):

$$k_1 \lor (\neg k_1 \land k_2 \land k_3 \land k_4) \quad (6)$$

Condition 2: "If a supplier profile is satisfying he should also have good production performances, if the supplier profile is not satisfactory attention should be paid to the financial aspect and the support and services." (**Eq. (7)**):

$$(k_2 \land k_1) \lor (\neg k_2 \land k_3 \land k_4) \quad (7)$$

Condition 3: "If the financial aspect is high, attention should be paid to the production performances, if not high, attention should be paid to supplier profile." (**Eq. (8)**):

$$(k_3 \land k_1) \lor (\neg k_3 \land k_2) \quad (8)$$

Condition 4: "If the support and services are high, attention should be paid to the financial aspect, if not high, attention should be paid to production performances and supplier profile." (**Eq. (9)**):

$$(k_4 \land k_3) \lor (\neg k_4 \land k_1 \land k_2) \quad (9)$$

Decision makers believe that for analysis of each attributes it is important to introduce weights for its sub-attributes. Besides weights, in some cases, it is also necessary to establish the logical condition between sub-attributes.

Condition 5: By analyzing attribute Product performance, decision makers find that sub-attributes Technical features and Quality are equally important and thus between them logical condition was established. For these sub-attributes a weight of 0.7 is assigned by decision makers and 0.3 for the sub-attribute Delivery. In this case, the sub-attribute function has the following form **Eq. (10)**:

$$0{,}7 * (k_{11} \land k_{12}) + 0{,}3 * k_{13} = p \quad (10)$$

Condition 6: Within the attribute Financial aspect, sub-attribute Price has weight 0.7. Sub-attributes Costs and Customs/fees have weight 0.3 and between them logical relation was established, what is given in **Eq. (11):**

$$0{,}7 * \ k_{31} + 0{,}3 * \ (k_{32} \wedge k_{33}) = \ p \tag{11}$$

Each of these logical conditions is transformed to the GBP, by using standard product as appropriate operator of GP. GBP in logical aggregation has the role of logical combined element. Transformation for **Condition 1** is given in **Eq. (12):**

$$k_1 \vee (\neg\, k_1 \wedge k_2 \wedge k_3 \wedge k_4) = \ k_1 + (\neg\, k_1 \wedge k_2 \wedge k_3 \wedge k_4) - k_1 \otimes \ (\neg\, k_1 \wedge k_2 \wedge k_3 \wedge k_4) = k_1 + \big((1-k_1) \otimes \ k_2 \otimes k_3 \ \otimes k_4\big) - k_1 \otimes \ \big((1-k_1) \otimes \ k_2 \otimes k_3 \ \otimes k_4\big) = k_1 + k_2 \otimes k_3 \ \otimes k_4 - k_1 \otimes k_2 \otimes k_3 \ \otimes k_4 \tag{12}$$

In the same way the remaining logical conditions are transformed, which is represented by the **Eq. (13, 14, 15, 16, 17)**:

$$(k_2 \ \wedge \ k_1) \vee (\neg\, k_2 \wedge k_3 \wedge k_4) = \ k_2 \ \otimes k_1 + \ k_3 \ \otimes k_4 - \ k_2 \otimes k_3 \otimes k_4 \tag{13}$$

$$(k_3 \ \wedge \ k_1) \ \vee (\neg\, k_3 \wedge k_2) = \ k_2 - k_2 \otimes k_3 + k_3 \otimes k_1 \tag{14}$$

$$(k_4 \ \wedge \ k_3) \vee (\neg\, k_4 \wedge k_1 \wedge k_2) = k_4 \ \otimes k_3 + \ k_1 \ \otimes k_2 - \ k_4 \otimes k_1 \otimes k_2 \tag{15}$$

$$0{,}7 * \ (k_{11} \wedge k_{12}) + 0{,}3 * \ k_{13} \ = 0{,}7 * (k_{11} \ \otimes \ k_{12}) + 0{,}3 * k_{13} \tag{16}$$

$$0{,}7 * k_{13} + 0{,}3 * (k_{32} \wedge k_{33}) = 0{,}7 * k_{31} + 0{,}3 * (k_{32} \otimes k_{33}) \tag{17}$$

Considering Supplier profile attribute, decision makers assigned following weights 0.6 and 0.4 for sub-attributes Reference and Brand respectively, shown in **Eq. (18)**:

$$0{,}6 * k_{21} + 0{,}4 * k_{22} = p \tag{18}$$

Taking into account attribute Support and services, decision makers determined following weights 0.5, 0.3 and 0.2 for sub-attributes Service, Technical support and Training aid respectively, presented in **Eq. (19):**

$$0{,}5 * \ k_{41} + 0{,}3 * \ k_{42} + 0{,}2 * \ k_{43} \ = p \tag{19}$$

Only once the transformations have been conducted and the final structure established will the values be introduced and computed [4]. This is the main difference between the conventional and Boolean consistent approaches. All tautologies and contradictions on the symbolic level are tautologies and contradictions, respectively, on the value level, as well [12].

By the inclusion of normalized k-values from **Table 3** in **Eq. (16,17,18,19)** sub-attributes functions were set and by the application of LA we obtain the values of alternatives (suppliers). The simple example of inclusion of k-values in **Eq. (16)** is given for a supplier S_1 **Eq. (20):**

$$0{,}7 * (k_{11} \otimes k_{12}) + 0{,}3 * k_{13} = 0{,}7 * (0{,}8 \otimes 0{,}6) + 0{,}3 * 0{,}4 = 0{,}456 \tag{20}$$

The values of suppliers for the four basic attributes are shown in the **Table 4.**

Table 4. The values of suppliers for the four basic attributes

	Production performance (K_1)	Supplier profile (K_2)	Financial aspect (K_3)	Support and services (K_4)
S_1	0,456	0,52	0,424	0,84
S_2	0,344	0,92	0,668	0,86
S_3	0,516	0,68	0,564	0,8

In the presented GBP equations **Eq. (12,13,14,15)** we will introduce the attributes values from **Table 4** based on which by using LA we obtain the values in **Table 5**. The simple example of inclusion of the values of suppliers in **Eq. (12)** is given for a supplier S_1 **Eq. (21):**

$$k_1 \vee (\neg k_1 \wedge k_2 \wedge k_3 \wedge k_4) = k_1 + k_2 \otimes k_3 \otimes k_4 - k_1 \otimes k_2 \otimes k_3 \otimes k_4 = 0{,}456 + 0{,}52 \otimes 0{,}424 \otimes 0{,}84 - 0{,}456 \otimes 0{,}52 \otimes 0{,}424 \otimes 0{,}84 = 0{,}557 \quad (21)$$

The values of suppliers for the four conditions are shown in the **Table 5.**

Table 5. The values of logical conditions for three suppliers

	Condition 1	Condition 2	Condition 3	Condition 4
S_1	0,557	0,408	0,493	0,394
S_2	0,691	0,362	0,535	0,619
S_3	0,664	0,495	0,587	0,521

The final ranking of suppliers is obtained by introducing TOPSIS method. In the previous steps we already calculated normalized and weighted matrix, so that we would implement the TOPSIS method starting from the third phase. The task of the TOPSIS is to determine PIS using **Eq. (3)** and NIS using **Eq. (4)**. As a reference points for PIS was taken $A^* = \{1,1,1\}$ and for NIS $A^- = \{0,0,0\}$. Following the calculation of PIS and NIS using **Eq. (5)**, it is possible to obtain the closeness coefficient (CC_i) for each alternative. **Table 6** shows the parameters PIS, NIS, CC_i and rank of the suppliers.

Table 6. Ranking of alternatives using TOPSIS method

	d*	d-	Cci	Rank
S1	1,08	1,04	0,49	3
S2	0,92	1,13	0,54	2
S3	0,88	1,14	0,56	1

In classic weight sum approach it is not possible to model their conditionality or connection between the attributes using the logical operators. The drawback of the weighting sum is that cannot be used to model logical expressions. Weighted sum considers attributes separately and cannot model interaction between them. It is necessary to introduce logic and logic operators, which can provide more operations for aggregation [9]. Thus, in this paper were introduced logical relation among attributes/sub-attributes which introduce verbal statements of decision makers, expressed as logical functions, in the decision making process. Logical functions result in a new structure of the components as opposed to the weighted sum approach. From **Table 6** we can see that the rank of suppliers is as follows: $S3>S2>S1$. In this way, the classical weight sum approach can be improved.

5 Conclusion

The reason of analysis of the presented model is primarily to provide practical support to decision makers when choosing suppliers in the telecommunications sector. In addition to solving the observed problems in this paper is used the weighted approach combined with the Boolean consistent fuzzy logic and TOPSIS method. IBA logic enabled the transformation of logic functions to a generalized Boolean polynomial, while by the use of Logical aggregation GBP is reduced to values. Ultimately, by using TOPSIS method ranking of suppliers ($S3>S2>S1$) was achieved. What makes this logic more suitable way to solve these types of problems compared to conventional fuzzy logic is that the structural transformations are performed before the introduction of values. Further research will be directed towards the inclusion of logical conditions into the multi-attribute decision-making method.

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Group decision making in oncology: A support through annotation management

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Abstract: We propose a software prototype based upon annotations management in palliative ward of an oncology hospital in which dealing with patients' state and evolutions is a complex organizational task. We develop a 5 years empirical investigation that is giving us broad and deep insights to characterize activity and offer an effective support for group decision making and collaborative activity of caregivers. We based our conception of annotation tool on the observations of the rich writing practices of medical professionals. We rely on the innovative strategy of intermediate management to introduce a new technology able to bridge heterogeneous valuable data flows that address both management support and activity support into a single tool.

Keywords: annotations management, complex tasks, caregivers' coordination, data flows management.

1 Annotations to handle complex environments

Our main research topic consists in the understanding and the computer support of organizing processes in uncertain, fast changing and complex environment [1]. We conduct an empirical and qualitative research in a palliative ward of an oncology hospital for more than 5 years. This led us to consider annotation practice and annotative process (to be defined thereafter) as the core elements of organizational work of caregivers in the ward to grab complexity and coordinate collective action in this highly evolving environment. We present in this paper a tool based on annotations management that we conceived for group decision making and for the support of work organizing practices.

In the first part of this paper, we will present a pluridisciplinary state of art about annotations management and about the relationships between writing practices, group decision making and negotiated collective work. We will develop our functional tool prototype for the organizing work in oncology based upon annotations. And finally, we will conclude and open discussion toward opportunities and limits of such an approach of collaborative decision support system.

2 Annotations and their management: state of art

Theoretically, we rely upon the Montreal school of text conversation model to address organizations and organizing process [10]. We also use Weick's concept of "*mindful interdependence*" to interpret specifically the way caregivers mobilize and act into an interconnected network of human and non human resources and actors to produce resilient and robust organization despite organizational complexity [11]. This theoretical frame is suitable to understand and analyze the intertwinement between texts production, oral communication, organization, technologies and patients management that we observe in our research ground.

While acknowledging flexibility, ease of use, but also hermeneutic and heuristic abilities of annotations, scientific communities that are involved with these practice-tools consider them in all our readings as a phenomenon. Annotation practice emerges due to complex environments, due to the "lack" of memory of workers, due to rigidity of formal and numeric documents. They are often pointed as a pragmatic response to complexity but they are never used as the core element of organizing processes [5, 8, 12]. Annotations are perceived as peripheral and secondary elements, which purpose is to enrich or interconnect texts or objects, to memorize temporary information or remember something to do. Annotations have been often described as structuring tools at a micro social level [5, 8]. Their features enable them to support cooperation and coordination modalities of small collectives of work. Annotation considered as a practice allows caregivers to capture quickly and easily relevant events in organization and care activity, to sort and synthesize elements (writer/reader dependant), to discuss specific elements during transmissions, to make hypothesis, to give instant access to these items through various medias [2], and to distribute collective awareness and watchfulness between members of the collective.

Annotations have the ability to interconnect and integrate synthetically various data sources and to assemble heterogeneous organizational elements (Fig 1.) (EPR, EMR[1], oral transmissions, artifacts of environment, scheduling,…). Annotations offer flexibility and ease of use that permit to answer to the milfoil of action modalities, superposed temporal constraints (physicians visits, patients' care, patients entry or exit, …), distributed data and complexities of situations in palliative ward [9].

From the reader point of view, annotations embark various "functionalities": todo lists, reminders, questions, interpretations, thoughts. They activate specific watchfulness thanks to writing modality (color, forms, underlining, "anchor"). Annotation is a powerful tool used to characterize, to remind, to coordinate, to develop *aboutness* and finally to manage patients' care context that contains many interweaved dimensions: medical, social, temporal, technical, cognitive, regulatory, organizational, and so on.[8]

From an organizational point of view, annotation practice that we observe in our research ground can be seen as a cultural practice that structures and configures organization of care work as much as it shapes the sociotechnical collectives [3]. As annotations are extracted from patients' context, negotiated and then put back in the

[1] Heath Information System, Electronic Patient Record, Electronic Medical Record

patients' history and trace into HIS bricks, they co-configure writing practices, as much as they are part of the group decision process as involved and "*agentive*" actors.

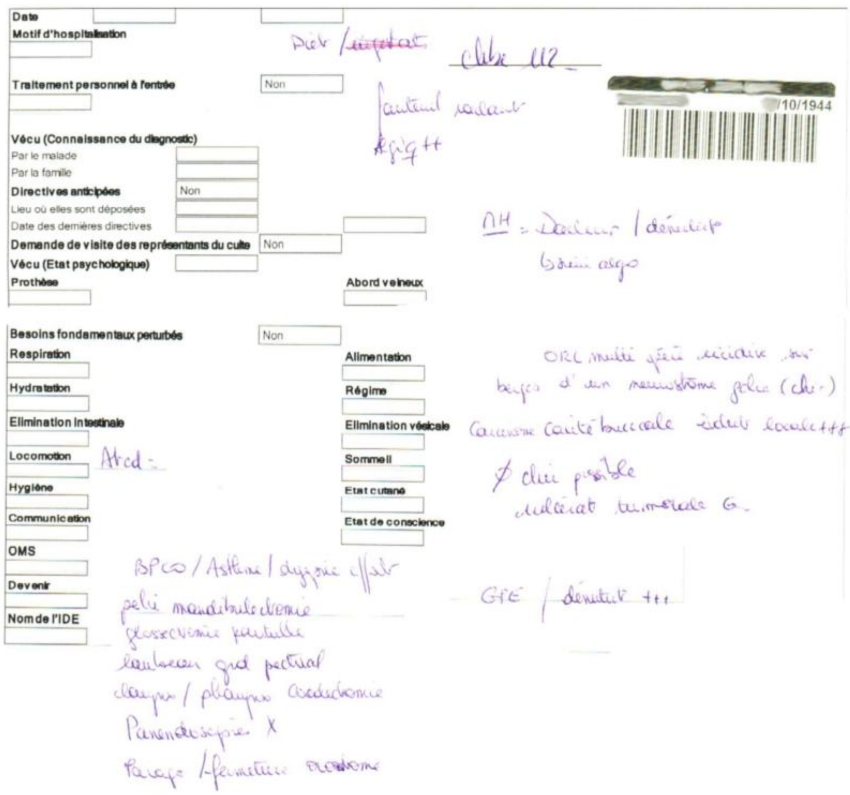

FIG. 1. The annotative practice: a nurse printed a patient entrance form (heuristic flow), added the room number and stuck patient barcode (institutional flow), added handwritten notes with data extracted from EMR (institutional flow) plus personal notes in order to plan further action (interview of patient and gathering of up to date data).

Finally, annotations can be seen as micro stories that are told and re-told many times a day by different spokesman in order to verify every piece of information about patients. It's a very collective work of *informational forge* which gives consistency to data, to patients' stories and trajectories, and to group decision that validates or invalidates parts or sometimes the entire therapeutic plan.

2.1 Annotations as the core of organizing processes: the annotative practice

Despite the huge amount of intrinsic qualities of annotations that our literature review and our ground observations point out, still the annotations are considered as second order elements, useful, but not as key objects of concern for group decision support or CSCW field. By now, we will formulate the hypothesis that annotations can be considered opportunely as constitutive elements – no more peripheral – in the production of documents and in the forge of organizational texts. Beyond documentary features, we will also characterize them as elementary bricks that are constitutive elements in the organization of medical work that is closely tied to text production that intervene in manage patients' pathology, trajectory and care [3]. Annotations are core elements of everyday practice of organizing in oncology ward. Caregivers rely on what we could call and characterize as an "*annotative practice*" to handle their complex environment of work and the complex situations of patients they take care of. This "*annotative practice*" deals with three *valuable* data flows (Fig 2.).

- The institutional flow mediated by EPR and EMR. This flow is impelled by professional regulatory constraints. It is often composed of a huge amount of exhaustive technical documents related to patients' history, disease, laboratory tests, imagery,... This flow is difficult to handle and use in everyday activity due to the *encyclopedic view* of patients that it provides. Hospital organization risk financial penalties if the quality and completeness of this flow is insufficient with regard to the law.
- To the *other side* of document valuable flows, we observe personal writings or very small collective writing flows, mediated by printed sheets heavily annotated during work. This flow can also be embedded in various artifacts (drug packing, sticky notes). This is the core flow of what we call the annotative practice. Caregivers literally rebuild a very rich and situated set of data to grab the world, understand the situations and act into the complex environment of palliative ward. This flow has two main inconvenient. It is hard to normalize due to personal practice of writing and it is produced outside HIS.
- The third flow we were able to observe is the result of an innovation driven by intermediate management of the palliative ward in order to articulate the two valuable flows depicted above. The caregivers in the ward developed iteratively a collective flow mediated by heuristic documents. This flow offers a synthetic view of all the patients in the ward in 2 page of A4 format. This text sheet is managed by the nurses of all the teams with a standard text editor and stored into a local file on the ward computer. This document is printed and annotated during work and used for oral transmission during team shifts.

These three valuable data flows act in different layers of the organization (institutional, collective, individual) but they are not independent from each other. Each flow is correlated to each other and produces either a frame or a complement to the others flows. These flows help caregivers in awareness and decision making, for therapeutic adjustment, and for the articulation, coordination and cooperation in the realization of the multiple and complex tasks they have to operate to take care of patients. These flows are melted all together thanks to document manipulation and during team shifts transmission. As these flows are produced by heterogeneous sources and contain both redundant and complementary data, caregivers *normalize* data flows by what we call an *annotative practice*. Caregivers use sort of *pivot format* namely annotations to mix and reshape heterogeneous data for their individual and collective purpose and then put data back into the right destination flow.

Thereby, we consider that organizing work is correlated to communicational processes mediated by and embedded in writing practices that are *co-constitutive of organization* [10] and that produce a network of *mindful interdependence* [11].

Our goal in the design of our prototype is to rely upon caregivers' innovative practice and to articulate these three valuable flows that address various organizational requirements into a single tool based on annotations.

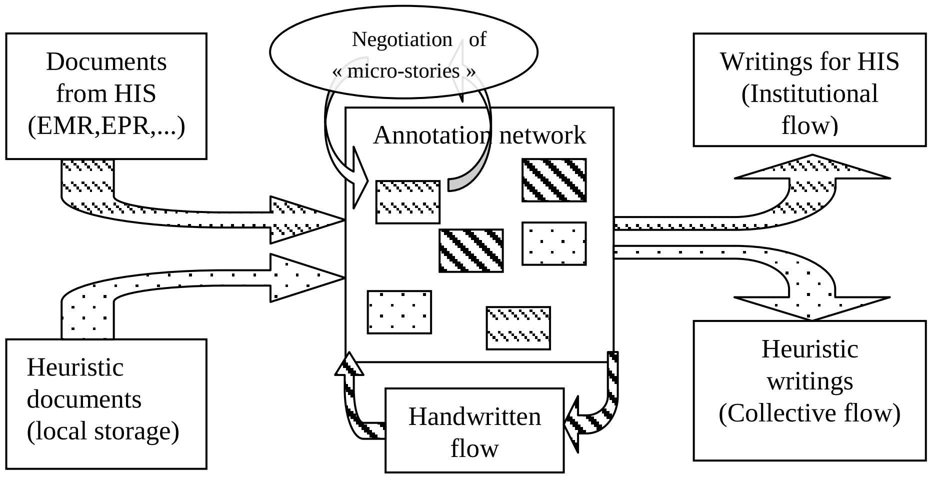

Fig. 2. Valuable flows and annotative practice cycle: Documents are split into handable pieces connected to each other (author, subject or target). Each piece is negotiated during team shift transmissions. Negotiated pieces are stored into a collective form and the cycle restart.

3 From empiric approach to software prototyping

When we take a look at tools such as social networks, participative conception tools, workflow modeling systems or ERP, users have the ability to define models of activity, plan actions, lists and organize tasks, make storytelling. But until now, the layer of organizing as we have presented is often neglected. *Tools on shelves* are often proposed as "*system as is*" from requirements engineering perspective[7]. But what we have learned from our empirical investigation and from our readings is the fact that in everyday situations technical systems are both *system as is* and *system to be*. Tools shape practices as well as they are shaped by repeated practices and experiments of caregivers. The only "*independent variable*" that we were able to point out, is in fact the annotative practice that we have just described. So, in order to reach the needs of caregivers and the requirements of standards, HIS and regulatory constraints, we need to go beyond the limitations of these tools and standards [4]. This is why we populate the organizing layer with "smart" annotations that reproduce writing practices and document forging practice of caregivers and why we also develop a prototype which is "system to be" that caregivers can design by themselves. Thanks to its functionalities, our tool can participate both in institutional and ambient organizing, offering flexibility, instant access, ease of use and more importantly robustness and resilience for the organization of medical activity. This overlay allows caregivers to articulate heterogeneous sources of data into a single "blender" in order to build a situated informational system connected to and interoperable with the institutional one. To address these issues, our tool provides three main functionalities. It first gives the ability to split documents of all kind into annotations network with references of original document. Then caregivers can manage organization of work and data through a connected network of "smart" extended and connected annotations. Finally, they can create composite tools above the annotation layer to give usable shapes to annotations network. Due to this article format, we will only develop annotation management.

3.1 Annotation modeling:

Annotation is the core object of our prototype. In other words, all the objects and class related to data flows management are extended from annotation class; annotation is the constitutive class of our application.
As annotations have the ability to transform objects into a single pivot format of data, we have to design them to be compatible with usual objects of writing practices, organizing and communicational processes. For example, we equip our annotations with event management features (begin/end date, repetition,…), messaging features (author/sender, recipients, attachments) or search / autocompletion abilities.
Here is the non exhaustive list of features of these smart annotations (Fig 3.).

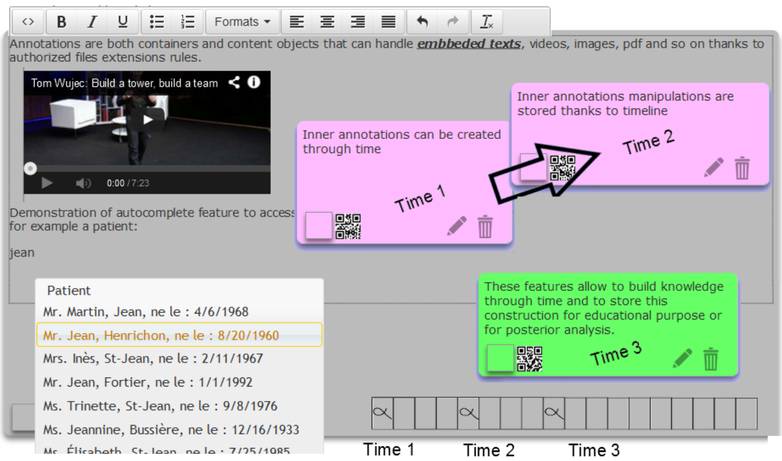

Fig. 3. Screenshot of annotations that illustrates some of their smart functionalities: multimedia container, cross reference preservation and autocompletion. Inner "timeline" holds synchronous or asynchronous updates of annotation content (versionChild) and inner annotations state.

Editing abilities of annotations:

- Annotations can handle content style layout (thanks to a wysiwyg editor)
- Annotations supports drawings (through a svg editor)

- They have an auto-complete feature which can connect them to external nomenclature (medical, equipment, patients or caregivers directory,…)
- They have a spellchecker functionality that allows caregivers to access various dictionaries, generate popup glossary and handle local vocabulary (in order to build local acronyms and maintain ontological reference to a term).

Containing abilities:

- Multimedia container ability (text, html, images, videos, attached content)
- Self containing: an annotation can hold and be held into an annotations net
- Have an inner timeline that manages internal states evolutions.
- Support multi-authoring.

Annotation model characteristics and class diagram:
We rely on the work of the OAC workgroup (Open Annotation Collaboration) paradigm for annotations model. We use this general frame for our annotation model in order to be compliant with web standards of connected objects and medical document standards (HL7) so to prepare our prototype for further integration (Fig 4.).

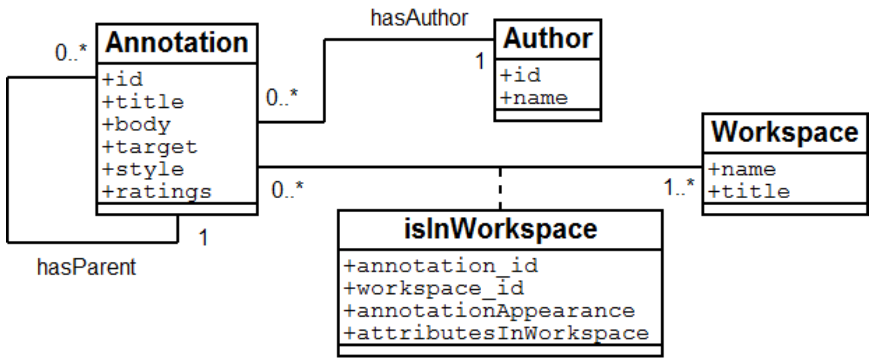

Fig.4. Simplified annotation class diagram.

Our contribution to these standards stands in the fact that our annotations embark: versioning, rich media management, "smart" data contextualization through nomenclature and dictionary connections, and internal timeline.

4 Conclusion

We proposed in this paper a new paradigm for group decision making and collaborative work support in oncology ward: the constitutive role of annotations to address organizational complexity and manage heterogeneous valuable data flows.

Our contribution to the domain relies in the proposal of enhanced functionalities of annotations based on deep observation of writing practices. Our proposal argues that translating this practice into a software design is full of interesting potentialities for group decision support domain. This allows to maintain a structuring, organizing and constitutive practice, and to build robustness and resilience by the intensive everyday usage of writing tool and the co-creation process that we observed [6]. The stake in our proposal is to go beyond annotation tools as a collaborative tool for collective writing. We propose to equip classical HIS with a layer of organizing based upon annotations to manage valuable flows of data and co-create organizing and mindful interdependence. This construction could help caregivers to build a culture of interoperable writings that both match activity needs and normative standards of medical documents. Hence, our tool could help to build a richer and extended writing culture toward professionalization of medical writings. For now, the prototype is under development and the tests step with real end-users is until yet not feasible.

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Analysis of the Audience's Acceptance to Discourse Focusing on the Sequence of Independent Words

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Abstract. Community transportation policy is an important issue for those who do not have personal transportation measure to live on. In this study, we try to clarify a mechanism how the community transportation policy is accepted by a special committee composed by the representatives of the inhabitants. Text mining was applied to get the utterance vectors for each talk. The local similarity of the utterance was calculated by the angle between a set of vectors. By using the calculated local indices about the topic sequence, logit regression model was estimated. The estimated model showed that the starting local sequence of a specific topic can contribute the acceptance of discussion conclusion, rather than following other's talk.

Keywords: Discussion Experiment, Text mining, Vector Space Model

1 Introduction

A planning for community transportation in Japan has been focused due to the difficulties to sustain local bus lines. The inhabitants who do not have own cars are in lower mobility in daily life. In order to redesign the local transportation service, a special committee composed of inhabitant, bus service provider and local government is often organized to find out a new community transportation policy [1]. For a transparency of decision making process, the records of the committee are often issued on website. An open access to public issue requires a careful management about the acceptance to the discussion from the non-participated inhabitants of the community, in order to overcome the conflict among the stakeholders [2], and to achieve a fruitful feedback among them [3]. Therefore, the quality of discussion in the committee should be kept higher in order to get understandings and supports to fulfill various requests or potential needs of the stakeholders.

There are several approaches to analyze group decision making. Klamler classified the existing mathematical approaches based on common structures of the problem setting [4]. Kibris reviewed the studies applying cooperative game theory to negotiation [5]. Kilgour and Hipel introduced several approaches in conflict analysis theories focusing on a graph model [6]. Parallel to the above normative approaches based on preference or utility theory, decision support system [7] or facilitation tools

[8] are proposed. Salo and Hämäläinen proposed multicriteria decision support system not only to evaluate policy alternative but to facilitate the decision process [9].

In terms of public acceptance to a policy alternative, Zoellner *et al.* focused on a public acceptance of renewable energies in German publics by a questionnaire, and the acceptance of new energy policies were analyzed [10]. Heras-Saizarbitoria *et al.* also studied in the energy policy in Spain [11], focusing on the longitudinal transition of the opinions on newspaper articles summarized by the authors. Koeszegi and Vetschera notified that an elementary unit of analysis in negotiation could range from micro (utterance) to macro (entire process) [12]. As a microscopic approach, text mining to count the key words in the documents based on syntax rules would shed light on the public acceptance to the prior discussions in policy. Dafouz-Milne compared the articles on newspaper about public issues with several countries, based on a text mining approach [13]. His study clarified that the “meta discourse” such as a style or way of discourse embedded in each utterances was significantly different over the countries. Text mining approach was also applied for public speech and its acceptance in Japanese [14], or in English [15].

This paper purposes to clarify how the acceptance to the proposed policy alternative by a special committee in which people did not participate is affected by sequence of utterances during the committee. For this purpose, we took a “discussion experiment” about community transportation planning by the members, and then the “discussion evaluation experiment” to evaluate the discussion by other community members was conducted. After watching the video of the discussion, a questionnaire survey was conducted for the others. In section 2, we summarized an aggregation analysis about the questionnaire survey in discussion evaluation experiment. On the other hand, a text mining was applied to the discussion record to make a quantitative index about the topic sequence, focusing on independent words. In section 3, the quantitative index for each talk is shown together with the frequencies of the judgment ground of acceptance. And then a statistical model in the acceptance of recommended policy alternative is estimated to find out the significant factors. The model includes a quantitative index calculated by using utterance vector as one of explanatory variables. Conclusions are shown in section 4.

2 Data Collection by Experiments

2.1 Discussion Experiment

Prior to a discussion evaluation experiment, we conducted a discussion experiment about public issue. The discussion topic was required to be a common issue among the monitors. Since the monitors were supposed to be university students due to easiness to sample collection, we set the theme as “introduction of car sharing system” at university. In order to attract the monitor’s interest on the discussion, a reward to the monitors was given, which amount is equivalent to the fee with tentative working as the time to join the experiment. The discussion group was composed of a

Table 1. Summary of Discussion Records

		1st wave	2nd wave	3rd wave	total
Num. of words variation		181	144	190	-
Num. of independent words / Frequency of talks	A	102 / 6	46 / 3	77 / 7	225 / 17
	B	101 / 6	95 / 6	58 / 2	254 / 14
	C	112 / 5	153 / 5	176 / 5	441 / 15
	D	162 / 7	61 / 4	20 / 1	243 / 12
	E	98 / 6	87 / 6	125 / 6	310 / 17
	F	89 / 6	55 / 3	86 / 3	230 / 12
	total	664 / 36	497 / 27	542 / 24	1703 / 87

facilitator and six monitors. The facilitator was a student in charge of this experiment. The facilitator mainly concentrated on a progression of the topics and did not so often propose a novel idea to the discussion. The monitors were collected from different departments in our university. The three of monitors owned a car they could use, while the others did not. They repeated three waves of discussion about the car sharing system, and the group was required to conclude a recommendation in policy alternative. Each wave of discussion was about 60 minutes. All the utterances in the discussions were recorded by an IC-recorder and a digital video recorder and these were converted into text documents with tag-number for each person's talk; in this paper, a sequence of sentences told by a person is called a "talk". To make the discussion active, some of fundamental information about car sharing and three initial options of the possible car sharing system including no-implementation alternative were given at first wave with some paper handouts. After the three waves of discussion, they chose a home-based car sharing system at selected spots, which was slightly modified from the initial alternative.

The result of morphological processing to pick up independent words from the records is shown in table 1. Here, the independent words are defined to have own sense by that word such as noun, verb, adjective and quasi-adjective. Since the facilitator was controlled not to propose a novel idea, we removed the facilitator's talks from the documents. As shown in table 1, the word variation in each wave (i.e. removing multiple counts for each independent word) was the least at second wave but the largest at third wave. The frequency of each participant's talk was almost even for all the participants at the first wave, but it became different in the second and third wave. An average number of words in a talk were around 18.4 for the first and the second wave, while it was 22.6 at the third wave. Since the words variation is not so different between the first and the third, the discussion had been concentrated into a specific topic with longer talk of a few participants.

2.2 Discussion Evaluation Experiments

In discussion evaluation experiment, we collected different monitors with the discussion experiment from our university, and 37 students participated to the experiment. The monitors were provided the documents recording all the utterances in three waves and the handouts about car sharing system at beginning. Then, they

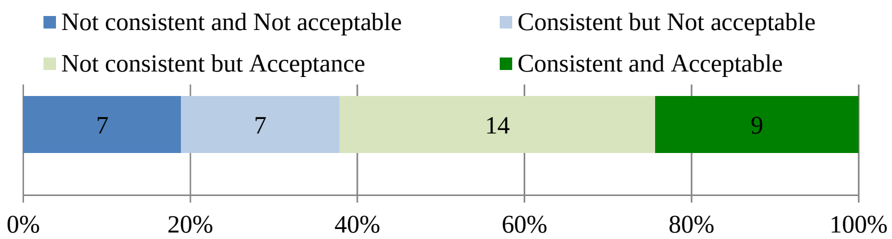

Fig. 1. Consistency with One's Opinion and Acceptance to Group Conclusion

watched the video at the third wave of discussion for 60 min., and answered a questionnaire about discussion evaluation. The questionnaire includes following 5 sections as 1) individual characteristics, 2) supporting alternative, 3) evaluation for the third wave, 4) acceptance of group conclusion and 5) evaluation for each participant of the discussion experiment. In section 3 and 4, we asked the tag number of the talks giving the judgment ground of acceptance.

Fig.1 shows an aggregation for discussion acceptance. The acceptance is asked with the consistency with the respondent's initial opinion, so then there are following four categories (consistent / not consistent and acceptable / not acceptable). As shown in this figure, over 60 % of the respondents can accept the group conclusion. It is interesting that almost 40 % of the respondents accepted the group conclusion even if the initial opinion for car sharing was different with it.

3 Statistical Analysis in Non-participant's Acceptance

3.1 Vector Space Model and Local Similarity

In order to get quantitative indices in topic sequence, a vector space model is applied to independent words appearing in the discussion records. In this model, each independent word is set as an axis of the utterance space and the frequency is plotted on it. Suppose a number of talks N^p at wave *p*, and a number of variations of independent words K^p at wave *p*. The utterance vector of talk *i* is in eq.(1).

$$U_i^p = \left(w_1^p, w_2^p \cdots w_k^p \cdots\right)^T \tag{1}$$

where $1 \le i \le N^p$, $1 \le k \le K^p$ and superscript T is a transpose of a vector.

A similarity between talk *i* and *j* is defined as a cosine of a set of vectors in eq. (2). For simplicity, a superscript p will be dropped, hereafter.

$$M_{ij} = \frac{U_i^T \cdot U_j}{|U_i||U_j|} \tag{2}$$

An average similarity of talk *i* to the other talks in wave *p* is in eq.(3).

$$M_i = \frac{\sum_{j=1}^{N^p} M_{ij} - 1}{N^p - 1} \quad \textbf{(3)}$$

Note that $M_{ii} = 1$.

The local similarity of talk i with the talks before three and with that after three are obtained in eq. (4) and in eq.(5), respectively.

$$Mb_i = \frac{\left(\sum_{i-3 \le j < i} U_j \right)^T \cdot U_i}{\left| \sum_{i-3 \le j < i} U_j \right| |U_i|} \quad (3 < i \le N) \quad \textbf{(4)}$$

$$Ma_i = \frac{U_i^T \cdot \left(\sum_{i < j \le j+3} U_j \right)}{|U_i| \left| \sum_{i < j \le j+3} U_j \right|} \quad (1 \le i < N-3) \quad \textbf{(5)}$$

The higher Mb_i indicates that the talk similar with the former talk so that the topic in the talk follows the previous talks. On the other hand, the higher Ma_i indicates that the talk similar with the following talks so that the topic in the talk provides the novel topic to be followed by the latter talks.

Fig.2 and fig. 3 show the transition of Mb_i and of Ma_i calculated by eq.(4) and (5), respectively, with the number of indicated talks as “Ground of acceptance” and “there

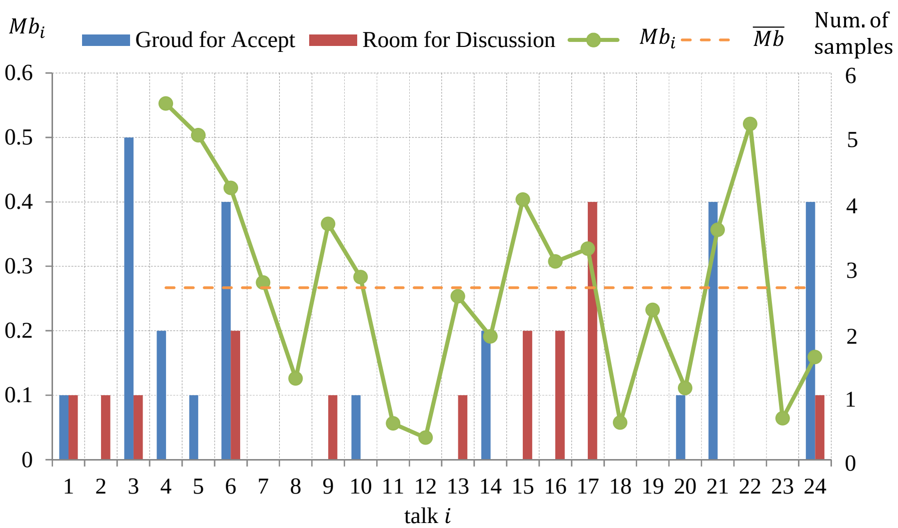

Fig. 2. Transition of Mb_i and Indicated Talks

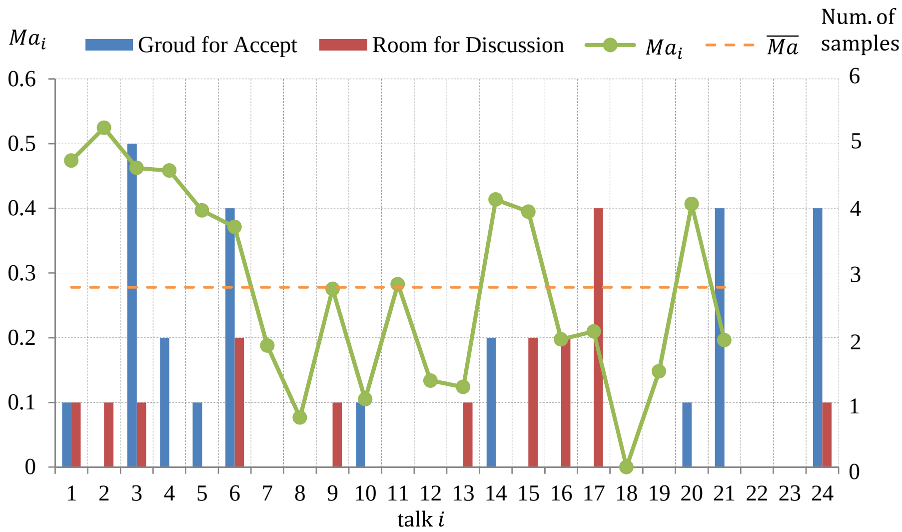

Fig. 3. Transition of Ma_i and Indicated Talks

are a room for further discussion", respectively. Comparing with the average of Mb_i, the higher values seem to be appearing at the talks giving the ground for acceptance infig. 2. The similar consideration can be obtained in fig. 3 for Ma_i, as that the higher values are appearing at the talks giving the ground for acceptance. On the other hand, the correspondence of a room for discussion with Mb_i or Ma_i seems bit ambiguous.

3.2 Acceptance Model to Group Conclusion

The acceptance to the group discussion is modeled by a binary logit, which objective variable is to accept the recommended alternative (y_i=1) or not (y_i=0) . The explanatory variables are selected by several trials and errors. As a result, knowledge for car sharing, car ownership, consistency of conclusion with the participant's opinion, rating for activeness in discussion, Mb_i and of Ma_i are adopted. The estimated parameter is shown in table 2. The likelihood ratio of the estimated model is 0.399, so then the fitting is well. In the table, positively estimated parameters indicate the positive factor to accept the recommended alternative and *vice versa*. Knowledge for car sharing and the car ownership were negative but not significant. Consistency of conclusion with the participant's opinion is positive but insignificant. Active discussion and Ma_i are positive with significant, while Mb_i is positive but not significant.

The insignificant parameter for the consistency of conclusion with one's opinion indicates that the monitors are flexible to change their mind, and they would carefully watch the discussion process. Therefore, the discussion experiment can provide the enough ground to judge the new community transportation policy. The activeness rating for the discussion is corresponding with our preliminarily expectation in

Table 2. Parameter Estimation in Acceptance to Group Conclusion

Variables	Estimates		T-value
Knowledge for CS (1: know, 0 : not)	-1.301		-1.26
Car ownership (1: own, 0 : not)	-1.921		-1.73
Consistency of conclusion with one's opinion (1:consistent, 0 : not consistent)	0.608		0.44
Active Discussion (rating, 5 ranks)	1.835	*	2.33
Mb_i by eq.(4)	13.897		1.53
Ma_i by eq.(5)	14.837	*	2.11
Constant	2.023		1.46
Maximum log-likelihood	-15.136		
Likelihood ratio	0..399		
Samples	36		

*: significance in 5%

parameter sign. The monitor's satisfaction to the discussion process is one of important factor. Mb_i' s insignificance and Ma_i s significance show that the starting local sequence of a specific topic can give a ground of the acceptance of discussion conclusion, rather than following other's talk. Since both of them are positive, the facilitator should manage the discussion to keep a topic for a while, and then to transit to others. As our experience tells, a facilitator should always care for the discussion progress to keep the pace of topic transition not too fast and not too slow. As shown in our experiment, if the discussion is well managed, potential participant (non-participants) will accept the recommendation from the representative committee, even the conclusion is different form the individual opinion.

4 Conclusions

In a matured society with stable growth, improvements and reutilization of existing infrastructure with an updated management policy become important. Since the self-governance in each community requires an aggregation from individual inhabitants to community will, the discussion about a community issue should be sophisticated.

This study tried to shed light on the discussion management and the improvement of public acceptance for a community policy such as a community transportation planning. Through the discussion evaluation experiment, the non-participated community members tend to accept the recommended alternative when the talk with new topic is followed by the others. Further, the participant can accept the alternative even it is different from the personal opinion. These findings indicate that the facilitator should care about the topic progress in the discussion as to sustain a new idea for a while. On the other hand, the rating for discussion activeness to the participants is different over the monitors, which is not expected. The reason for it would be the participant's difference in background knowledge for the discussion topic. This is to be fixed in the next experiment.

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A Reflection of the EWG-DSS's Life through the Application of SNA Techniques to its Publications

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Abstract. In the last decades, scientific collaboration analysis has benefited of improvements in techniques and tools that support networks analysis. Taking advantage of these opportunities, the Euro Working Group on Decision Support Systems (EWG-DSS) launched the Collab-Net project. This project aims at analysing the life of the group. Emerged as an autonomous parallel thread within the project, the work reported in this paper studies the publications generated by the activity of the group for the decade 2003-2012.
The analyses reported here apply Social Network Analysis (SNA) techniques to explore two axes. The first one studies the co-authors' network and studies authors' involvement and their positions within this network. The second one examines the keywords associated to these publications and, considering the network of their co-occurrences, proposes some elements about the domain covered by the selected set of publications.

Key words: EWG-DSS, SNA, co-authorship, keywords

1 Introduction

For several years, the Euro Working Group on Decision Support Systems is interested in the evolution of the network formed by its members. The project, launched to follow and analyse the community, is known as the EWG-DSS Collab-Net Project. The first results have been published in several papers [1, 2, 3, 4, 5, 6, 7, 8]. They particularly highlighted the leadership position of some of the early members among which the committee members. Moreover, these last ones are acting as efficient bridges within the community. The roadmap for the future of the project is drawn in [9].

Taken an alternative path with respect to this agenda the present piece of work studies the network through the set of publications issued from the events organised by the group. Indeed, since the creation of the EWG-DSS in 1989 several events have been organised. Together with the committee meetings and streams in the EURO conference organized since the early years, the group proposes now workshops and tracks in mini-conferences. Moreover, these events do not only give rise to proceedings but also, extended versions of selected best papers are published in special issues of journals and in books.

With respect to the original program, this restricted set of publications provides a limited view on the real activity of the members. Therefore, the project is still running and a platform to support a sound data collection process is under development. However, focussing this piece of work on events and editions managed by the group offers interesting aspects:

1. the data collection is complete and does not suffer methodological discussion;
2. moreover, the available information involves not only title and authors but also keywords and abstracts;
3. the study enhances the part of the activity of the members whose association with the group is obvious.

The paper is structured as follows. After a few words on the data collection and the methodology, similar works applied to other communities are briefly mentioned. Then, the results obtained using the social network analysis (SNA) techniques are described in two sections that cover the two main axes of the analysis. The first one studies relations between the authors in the network. The second axis is dedicated to the keywords analysis and identifies the main areas in the domain covered by the publications. The last section draws some conclusion and lines for future work.

2 Methodology

2.1 Data Collection

The data collected for this work cover 10 years of activities of the EWG-DSS from 2003 to 2012. They consist of

– streams in 4 EURO conferences (Prague 2007, Bonn 2009, Lisbon 2010 and Vilnius 2012)
– 4 (co)-organised workshops (Graz 2005, Paris 2011, London 2011 and Liverpool 2012),
– the co-organized International Conference on Creativity and Innovation in Decision Making and Decision Support (CIDMDS London 2006)
– the co-organized International Conference on Collaborative Decision Making (CDM Toulouse 2008)

Moreover, 10 journal special issues (IJDSST [14, 16, 17, 18] GDN [15], EJOR [10, 13] CEJOR [12] and JDS [9, 11] and one book [19] involve extended versions of selected best papers.

The choice of the initial year of 2003 corresponds to the first edition of a special issue [9] by the group and initiated a period of significant activity as confirmed by the list above. Limiting the period to 10 years (2003-2012) offered both a symbolic size and the warranty of access to the complete information at the time of launching the work (2013).

2.2 Data Preparation

Thanks to the support of the EWG-DSS committee, obtaining complete information was not such a big deal. Even if complete, the data set still required some pre-treatment. The classical disambiguation and synonyms identification in the authors' name required some attention; but given the limited size of the data set (less than 300 publications), it was efficiently managed by hand.

Regarding the keywords, the job was a bit more demanding. Indeed, the chosen approach consisted in respecting authors' choices and use the author-defined keywords. However, this does not completely avoid some pre-treatment. In a first step, the identification of synonyms required a bit of care (consider f.ex. MCDA, Multicriteria Decision Analysis, Multi-Criteria Decision Analysis and all the variation with or without capital letters, among others). Complementarily with this cleaning, some very specific keywords have been completed with a more generic one. For example, "k-means range clustering" appear as such for only one paper and so get lost in the ocean of the keywords. Addition to the concerned paper, of "clustering" and "data-mining" improves the quality of the networks in two ways: on the one hand the specific keywords turn to be connected with the network, on the other hand, the more generic term "data-mining" receive relevant connections. This tactful association of keywords has been done following recommendations of the committee members of the EWG-DSS.

2.3 Statistical an SNA Methods

The summary of three large networks studies realised in [21] present and compare co-author network in biology, physics and mathematics. The sizes of these networks (several 10.000 and more) do not allow comparison with our piece of work, but the relevance and the interpretation of observed parameters adopt a similar methodology.

In [22], authors apply social network analysis techniques to the co-author network extracted from the publication in the journal Scientometrics from 1978 to 2004, they firstly compute global metrics on the network to describe the micro-structured of the collaboration network, then they provide a description of the identified clusters on the basis of the most frequent words appearing in the co-authored titles. In this cluster analysis, the network is limited to authors involved in at least 3 publications. The current piece of work adopts a similar microstructure approach of the co-authorship analysis. But regarding topics, we choose a global view and focussed on keywords instead of titles.

Words' occurrence in title is also used by [23] that studies the evolution of communities in publications inventoried on DBLP, the authors propose a methodology to follow the temporal evolution of communities defined by common interest.

3 Authors' Network Analysis

The analysed set of publications involves 218 abstracts and papers in proceedings written by 417 authors and 78 papers in journals and book, by 207 authors. Most of these 78 are revised and extended versions of the works presented in the proceedings.

Among the 218 publications in the proceedings, only 50 publications are single author, others involve 2 to 7 authors, only one involves 10 authors. Figure 1 presents the network of the authors obtained by connected authors that are involved in (at least one) common publication, and self-looping authors appearing as single author.

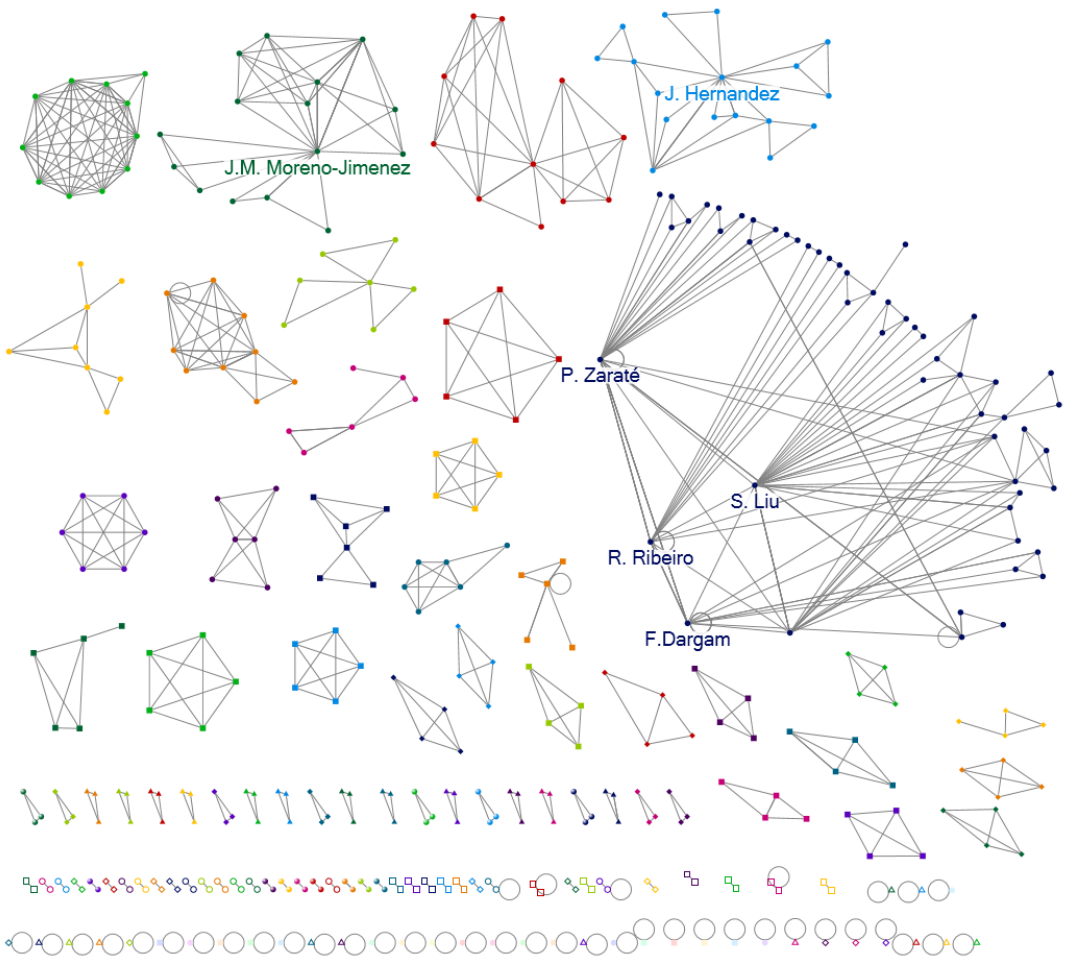

Fig. 1. Proceedings co-authors network (realised with NodeXL)

Average degree (5,5 for proceedings, and 2,7 for journals) and density (0,0115 for proceedings, and 0,0131 for journals) of the network are quite low. However, the group members are not single players... This claim can be supported on the one hand by the small number of single author papers and on the other hand by the observation of the connected components.

Indeed, 50 (23%) publications have a single author, but only 36 (9%) authors appear only as single authors. Regarding the journal publications, single author papers number drop to 8 (10%), and only 6 (3%) authors are always publishing alone. The average number of authors per publication is 2,6 for the proceedings and 2,9 for the journals. These appear to be higher than results obtained by studies in other domains [22]

Considering the graph of authors involved in proceedings (illustrated on figure [1]), a huge set of components (at the bottom of the figure) corresponds to single authors or subset of authors involve in only one (common) publication. The interesting connected components are theones that connect groups of co-authors that do not (or not always) publish all together. Among them 4 components involving 10-20 authors (the four first ones on top row). A single big component (the giant component of the network) involves 53 (13%) authors.

The giant component illustrates how the early commity members (F. Dargam, R. Ribeiro and P. Zaraté) are bridging the community. The three components on the right of the top row illustrate the position of active members involved in multiple co-authors teams (as J.-M. Moreno-Jimenez and J. Hernandez). The particular component on top left of the figure corresponds to one publication written by ten co-authors. Four of them collaborate with an eleventh author to another publication.

The centralities (degree, betweenes and eigen vector) analysis confirms the leadership role of committee members already identified in previous publications.

4 Keywords' Network Analysis

The set of 479 keywords are extracted from the same set of 218 abstracts and papers published in proceedings. Their co-occurrences in a publication define 1486 connections. The resulting network involves 18 connected components:

- 428/479 (89%) nodes in the big component
- 51 other keywords are involves in 17 small components each one corresponding to one publication.

A part of the size of the giant component is due to strong attractiveness of DSS (59 papers, centrality degree 128) and MCDA (26 papers, centrality degree 81). However, even cumulated they do not explain half of the size of the component. This strong inter-connection may suggest that the domain covered by the EWG-DSS is well identified by the participants. However, there is also place in the events for more presentation of work more "off the beaten track".

The top 10s of the centrality study are presented in figure 2. The degree centrality is highly related to the frequency distribution of the keywords. One can

	Degree Centrality		Betweeness Centrality		Eigen Vector Centrality
DSS	129	DSS	35167,058	DSS	0,031
MCDA	82	MCDA	14981,425	MCDA	0,023
Collaboration	74	Decision-making	12561,561	Collaboration	0,021
Decision-making	56	**Data-mining**	12301,335	Collaborative Decision-making	0,015
Network	53	Collaboration	12274,075	Network	0,015
Data-mining	52	Network	10385,060	Decision-making	0,014
Collaborative Decision-making	42	**Information**	5705,440	Knowledge management	0,014
Knowledge management	36	Optimization	5127,642	Data-mining	0,013
Group decision	34	**Performance**	4765,470	Group decision	0,013
Optimization	31	Collaborative Decision-making	4134,206	**Multicriteria Decision making**	0,011

Fig. 2. Keywords Centralities

already observe that a variety of domains is covered by this top 10. Betweeness centrality reveals node that act as connectors between elements in the networks, observe the apparition in this top ten of “Information” and “Performance” and the progression of “Data Mining”. This suggests their “service” role in many different areas of DSS. The eigen-vector centrality by taking weights of nodes and connections into account, reveal the node how are strongly connected to the strong actors, and in this top ten appear “Multicriteria Decision-Making”.

The Louvain method [20] has been shown efficient in identifying “communities” in graphs. Its application to our keywords networks, limited to nodes with a degree above 5 (involved in at least two publications) provide a five axes decomposition. For sake of readability, figure 3 provides their visualisation limited to nodes with a degree above 12.

These axis are as follows (starting from the longer one on the right and turning clockwise):

- axis 1: DSS, Decision making, Network, Data-Mining, Simulation, Optimisation, Fuzzy, Supply chain, Performance, Decision support, Case study and Risk,
- axis 2 : Collaboration, Collaborative decision making, System science, Multi-agent system, MDA, ERP
- axis 3 : MCDA, Group decision, Multicriteria decision making, Decision-making process, Preference, AHP, Sustainability
- axis 4 : Information, Uncertainty, Statistics, Bayesian, e-management, software engineering
- axis 5 : Knowledge management, Production, Model.

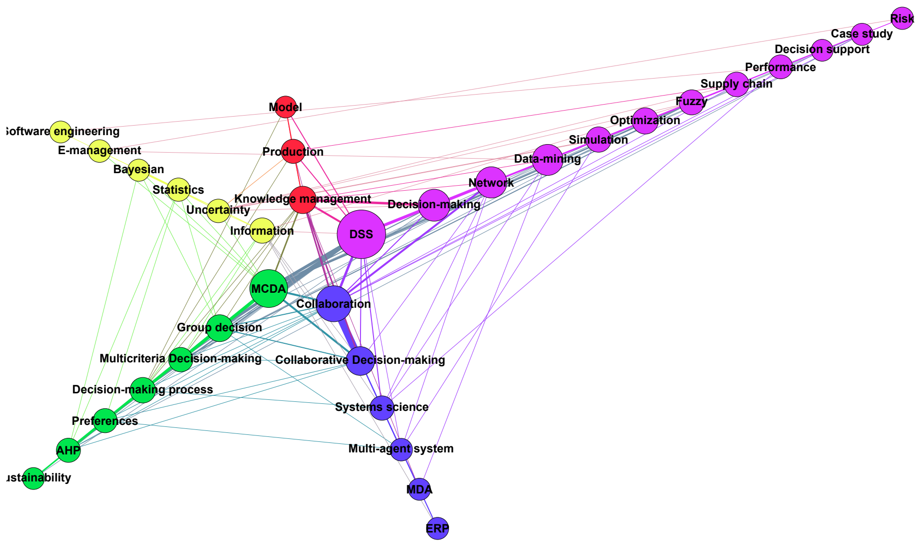

Fig. 3. Five axes decomposition of the keywords network (generated with GePhi)

5 Conclusion and Future Work

The current piece of work proposes the early stage results obtained by analysing 10 years of publications within the EWG-DSS activities. Two networks have been studied in this paper. On the one hand, the co-authorship network enhances the organisation of the group. And, on the other hand, the network that links the co-occurring keywords explores the structure of the "Decision Support System" domain.

Further analyses are under investigation on the same data set. After the qualitative analysis presented here, the weighted graphes will be consider. The two graphes will also benefit from the application of overlapping community detection techniques [24, 25] which should provide more robust results regarding both the community structure and the domain analysis. Similarly, opportunities offered by the apllications of hierarchical clustering techniques and Hyper-graphs methods have to be investigated.

The information about the evolution in density and strength of the network will offer a temporal view which will be explored by dynamic community dectection [26] and the quantification of this evolution [27].

Specifically for the authors network, distinguishing members and non-members of the EWG-DSS will deepen the results.

Regarding the keywords study, the approach based on author-defined keywords, will be completed by the association of "topic" through text-mining analysis of title and/or abstract.

This study of the keywords underlines high variations in authors' strategy to define them, this opens many questions on the best practices. A by-product of the research could be a set of recommendations that the group could provide to authors presenting their work in its events.

By adding the citations in the data set, a third network can be formed that connects publications. Citation and co-citation analysis methodology is describe in [28]

Finally, summarizing the survey realised in order to support these specific analyses, a more generic contribution will consist in the development of a methodolgical framework to analyse the evolution of a scientific community.

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Epistemological Analysis of Decision Making - An Application to Trust

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Abstract. Decision-making systems based upon multi-agent technology have epistemological implications that are seldom acknowledged. We provide a simple analysis arising from the method, inspired by theorem proving, we have designed along the years. We also specify the link with Web 3.0. The results of this analysis are applied to a new approach to trust making use of securitization. An important consequence of such an approach is to emphasize the interdisciplinary features of decision support systems.

Keywords: Decision making, agent, sociology, virtual knowledge, culture, topology, trust, securitization.

1 Introduction

We are concerned with the problem of decision making by multiple collaborating agents for knowledge systems in the framework of Web 3.0, i.e. in situations where knowledge is widely distributed. The goal of this short paper is twofold. The first one is to understand the contents and implications of such a knowledge challenge without restricting it to keywords. In generic wording this is what is called usually epistemology or theory of knowledge. The second one is to investigate the whole trail between a theoretical challenge and the business application. This is what a business plan is expected to do. Although the framework is very generic, we want to outline that it is suitable for addressing one of the main challenges of modern IT: trust.

The epistemological part of this report is based upon previous works [1 and references therein] of us introducing technical contents. Here we outline an analysis resulting from the technical contents. What is also fully new is the model we propose for trust that includes in particular a concept of securitization of trust. We must add as a remark that we are aware that the link between epistemology and knowledge is not as straightforward as suggested by our introduction. This has been much discussed for many years. However, we do not need to enter such discussions for our purposes.

A trivial preliminary remark is to note that very many factors do affect one's ability to make decisions in the domain of economics. For instance, the doctoral thesis of Anna Dreber Almenberg, entitled "Do sex hormones impact our economic decisions?" was nominated in 2013 for an award of the Stockholm School of

Economics. The program of Anna Dreber Almenberg conducts a series of experiments investigating how some sex hormones affect decision-making. Can they make us take more risks, or become more self-sacrificing or more competitive? We will exclude such behavioral facets of the economical investigation from our analysis. However, it could be included in the multi-agent model we select.

2 Web 3.0

Since its origin, between 1990 and 2000, the Web has seen several evolutions. The present one is labeled Web 3.0 (name suggested by John Markoff of the New York Times) and refers to a web more connected (IPV6, HTML5), more open (Web of data, Web of things) and more intelligent (content disambiguation, reasoning).

Tim Berners-Lee, the Web initiator, has described the Semantic Web as a main component of Web 3.0. It aims at describing one of the main features of Web 3.0: a Web of data that can be processed by machines. This means that the Web is now structured when compared to the previous versions.

A recent call for papers of the Semantic Web journal emphasizes an obvious link between Big Data and Semantic Web. It is phrased as follows: "One of the key challenges in making use of Big Data lies in finding ways of dealing with heterogeneity, diversity, and complexity of the data, while its volume and velocity forbid solutions available for smaller datasets as based, e.g., on manual curation or manual integration of data". Semantic Web technologies are meant to deal with these issues, and indeed since the advent of Linked Data a few years ago, they are becoming central to mainstream Semantic Web research and development. We can easily understand Linked Data as being a part of the greater Big Data landscape, as many of the challenges are the same. The linking component of Linked Data, however, introduces key features for the integration and conflation of data across multiple sources.

This is a fully meaningful description of the problem generated by the huge amount of available data for decision-making in a distributed environment. The integration of the Web of things is an additional facet to this approach, since any Linked Data network must be able to host the connections to Internet objects.

The specification methods lying at the heart of our framework [1] are fully suitable for Web 3.0. The suitability means that we do not have to introduce the features listed previously to specify the Web 3.0 but that they are already built in the framework we are designing. Unfortunately, because of the format of the paper we cannot detail more this fact.

3 Topology

The use of topology in knowledge representation is an old story. For instance, the map of the London underground is nothing else but a topological representation of the existing lines. Nowadays, topology is being used to manage huge data sets as described in [2] for instance. Along similar purposes, we introduced in [3] the concept of logical fibering as an abstract data structure well suited for dealing with huge or smaller data sets. We investigate links between topology and AI along the following lines. Multi-agent system is a concept of distributed AI. The design of advanced models for AI computing faces some well-known challenges. Besides the processing of huge amounts of data one of them is knowledge engineering. This implies especially to define and extend the range of what is computable or not. The traditional solutions were to select specific logics or knowledge management methods as shown by any introductory book on AI. Nowadays, there are attempts to extend the limits of Gödel's theorem and the variety of Turing machines. These approaches are often summarized under the label of universal AI. There is also an attempt to define specific approaches such as "formal concept analysis". It is a formal concept in communication between types and attributes with origins in philosophy and sociology.

Epistemology reminds us that a few years ago mathematicians were defining AI as heuristic computing. It looks thus like going backward to rely on methods expressing through mathematical concepts the notion of heuristic computing. Any mathematician knows that fibers are enumerable. Thus, there is a strong motivation to introduce logical fibering as a relevant data structure. Similar arguments are presented in [5] in the framework of essays on scientific and philosophical understanding of foundation of information and computation. Such an analysis belongs obviously to an epistemological approach of the problem. The same author analyses further how basic concepts can be found lying in mathematical description in a paper entitled "From Descartes to Turing: The Computational content of Supervenience". The first author of this paper also pointed out the role played by Descartes "Discourse of the Method" on the early influences of philosophy and mathematics in [6].

The concept of logical fibering makes it possible to define a new type of Turing machine [15]. This provides a solid link between topology and AI computing.

4 Corporate Knowledge, Culture and Trust

The framework we do select in [1] is based upon multi-agent systems. But we have a slightly different definition of what an agent is compared to what most authors have. We introduce an agent oriented abstraction [4] enabling to label as agent humans as well as artifacts. For instance a simple thermostat is an agent since it makes a decision (to find the temperature) and can communicate (to display the temperature). The application to the Internet of Things is then straightforward.

At this stage several epistemological comments are in order. A first one is that systems of agents are in fact societies of agents. To define what kind of society we consider, we have to emphasize that we enforce the paradigm that the societies are defined by the actions of their agents. This means that we rely on the theme of social expectation and on the principles introduced in Sociology by Weber: the actions of the agents determine the society they build and not the converse. Another remark is to distinguish between a society and its governance. It is well understood that (even in everyday life) the governance of a society is a challenging question. It is even more obvious for multi-agent systems since the problem is usually overlooked and society and governance are mixed without analyzing the implications. We make a strong distinction between society and governance. Thus, our framework is suitable for studying social relationship and networking in the context of sociological features for culture and social networks. We state that these are not general implications but as noted in [4] consequences of the method of Weber and its implication with the Theory of Games and Economic Behavior as introduced in 1944 by John von Neumann and Oskar Morgenstern.

The building stones of our implementation are the so-called "Virtual Knowledge Communities (VKC)". They are tools simple to implement and to reason about [11, 12]. We define a society of agents but not its governance. It is up to the designer of the system to define its governance. In political science, this is usually defined as the proximity and accessibility of the agents and the governing body.

We have shown [11] that this definition of agents is suitable to define a company through its corporate knowledge. Even the communication methodologies among the various entities of a corporation are defined through VKCs.

As for any methodology, the challenges are privacy, trust and security. We will emphasize this for intercultural communications where to enforce trust is mandatory.

The next step is to claim that culture belongs to the corporate knowledge of a nation of an international grouping of countries or of a corporation. We assume the very different approaches to culture that are investigated in various areas nowadays. Linguistic is a distinct one assuming that most troubles arise for an imperfect mastering of the languages. Economists do identify some criteria that are gathered in models and then assessed for a better accuracy. Sociologists are right to suggest that societal organizational features are at the origin of troubles. Philosophers will tend to put more weight on the native way of thinking of cultural groups, taking into account history and geography. Engineers with a solid background in management may propose meaningful changes in the decision making process. We do not claim that we have a new approach to what culture is. We simply claim that we can adopt any of these approaches, transform it into a knowledge management process that can be abstracted as Abstraction-Based Information Technology along the following lines:

- A theory is an ontology,
- The control means to infer facts from this ontology. It is a decision making process,
- The environment consists in specializing these facts to a specific cultural group.

Trust and culture did attract much attention in Sociology. A very rich book [13] is restricted to French-German cooperation but displays a large collection of intercultural troubles that are easy to find and difficult to solve. Although Germany and France do collaborate extensively for many years now, their collaboration is still prone to acute troubles. Paper [14] reports on trust and culture in virtual organizations. It is only one among many reports devoted to this topic. These two documents [13, 14] are written by sociologists in the framework of sociology. Our goal is to solve similar conflicts but with tools from Artificial Intelligence. The knowledge detained by people belonging to an organization is part of the corporate knowledge. Additional knowledge is detained within the IT system. Moreover, corporate knowledge is composed of some communication means for exchanging information. Considering the definition of the VKC abstraction, we claim that it is a convenient abstraction for Corporate Knowledge. Indeed, VKC strongly supports the principle of autonomy of actors (individuals as well as artifacts). Actors hold knowledge and decision ability (algorithm). Thus, VKC allows building corporate knowledge in a bottom-up approach, which is fully compliant with real world processes and which can be implemented for fuzzy but effective knowledge exchanges and management. In [11, 12] we showed how to model corporate knowledge using VKCs. The latter look like knowledge bases and can be thought of as knowledge systems also.

5 Securitization of Trust

In our approach trust has several facets. Most of them are related to the context that can affect the belief in a "statement". In most cases the context can be represented by knowledge bases, in our model VKCs. Then, trust results from the exchange, sharing and mixing of knowledge bases. These operations can be disturbed by any intruder thus the idea to distribute knowledge as done for assets in finance using securitization. To start from we simply rely on definitions provided by Wikipedia: "Securitization is the financial practice of pooling various types of contractual debt such as residential mortgages, commercial mortgages, auto loans or credit card debt obligations and selling said consolidated debt as bonds, pass-through securities, or collateralized mortgage obligation (CMOs), to various investors. The principal and interest on the debt, underlying the security, is paid back to the various investors regularly. Securities backed by mortgage receivables are called mortgage-backed securities (MBS), while those backed by other types of receivables are asset-backed-securities (ABS)".

The concept has been made famous during the sub-primes crisis. But, it was already introduced in the area of international relation by the so-called Copenhagen's school as a synthesis of constructivist and classical political realism in an approach to international security [7]. This is not far away from the domain of trust that we investigate. It also implies a strong semantic meaning for each involved concept.

Another interesting recent piece of work is in the domain of re-insurance and achieved at the London School of Economics by Barrieu and Louberge [8]. They consider a simplified economy composed of three different types of agent, namely an insurer, a reinsurer and a representative investor. The exposure of the insurer can be diversified within a larger portfolio. The reinsurer can transfer part of its risk to the capital markets by sponsoring an insurance related bond. The decision criterion is based upon existing regulations. More precisely, the different agents considered assess their risk using a convex risk measure. For the sake of simplicity, they consider entropic risk measures in order to derive explicit formulae for the different quantities involved. In our framework, we can use well-known concepts of information theory. In information theory, Shannon entropy represents the information content of a message or, from the receiver point of view, the uncertainty about the message the sender produced prior to its reception. The Kullback-Leibler distance or relative entropy can be used to define a "distance" between two discrete sets. Basic definitions can be found in [9]. A more general introduction to the relationship between entropy and knowledge is given in [10].

At this stage it is worth asking whether such ideas are relevant or not in economy. A supporting idea is in fact provided by the announcement by the Nobel committee of the laureates in 2013 for trend spotting in assets market. It is as follows: "There is no way to predict the price of stocks and bonds over the next few days or weeks. But it is quite possible to foresee the broad course of these prices over longer periods, such as the next three to five years. These findings, which might seem both surprising and contradictory, were made and analyzed by this year's Laureates, Eugene Fama, Lars Peter Hansen and Robert Shiller". This award unifies two lines of thinking that may be seen as opposite. We interpret it as a proof that there is a need to further the concept of trust and investigate new approaches.

A key remark is that trust results from sharing and exchanging knowledge bases. Thus, the link to our epistemological analysis ought to be now clear. Another link is the fact that we must be able to store very large amount of data. To this end, we use logical fibering as abstract data structures. Another feature is that logical fibering can be tailored to carry values of selected function as it is done for securitization in financial mathematics.

6 Draft of a Business Plan

The main steps of a business plan as taught in any business school cover well-known domains. A first one deals with the market environment and assesses the macro-economical environment, the market size, the consumer behaviors and an analysis of the competitive situation. A second one is more specific for the product under consideration. It evaluates the product, the localization or place, the price and the marketing or promotion expectations. The third one is usually referred to as SWOT (Strengths, Weaknesses, Opportunities and Threats) [16]. It covers both the external and internal criteria that an enterprise must face, including regulations and laws. Finally there is usually a finance plan covering between 1 and 5 years of business activities.

At this stage we do not want to fine analyze a business plan for Web-based business. A first remark is that if no company can start without a business plan, it usually proves itself to be inaccurate within the first months of activities, even when the company is successful. Such a comment is routinely made by most of business founders but usually not written down. This is a weakness that can be corrected. Indeed, each of the points mentioned in a business plan is a decision making step. We claim that having decision making modeled as theorem-proving process formalizes most of the steps of a business plan (once a product has been selected) and thus there is hope of a more meaningful business plan.

As mentioned previously the discourse on the method of Descartes is probably the first business plan presented to get a financial support. That it is mathematically oriented is almost trivial when translating "essences" into "axioms".

A complementary remark is that Virtual Knowledge Communities (VKCs) are fully suitable to represent each step of a business plan. Then, the trust model outlined in this paper ought to increase the confidence level given to a business plan. This arises from the fact that any company can be modeled through VKCs and such a fact provides the skeleton of a business plan. More precise characteristics can be introduced as annotations within the logical fibers.

7 Conclusion

We have broadly outlined several concepts that arise from an epistemological analysis of decision-making system based on a specific multi-agents and theorem-proving technology and web-based communities. The resulting framework is fully suited for group making decision since each agent in the game can be regarded as carrying one decisions making actor. It is tailored for Web 3.0 because we do not distinguish between artifacts and humans and thus can readily model the Internet of Things.
Due to the required format of the paper and to the large multi-disciplinary scope of the problem, it is not possible to get into technical details.

Works in progress on logical fibering applied to the identification of denial of service attacks [15] and on the design of an Erasmus coach will bring more understanding. The topic of securitization of trust will also be better described in a forthcoming publication.

The main lesson to be learned from this brief outline is that it is not possible to ignore the epistemological consequences of decisions based upon some fashionable keywords. To put it gently, let us add that one cannot use a multi-agent system without understanding the conditions arising from the gathering of such agents into a society.

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Towards a Web-Based Spatial Decision Support System for the Multiple Capacitated Facility Location Problem

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Abstract. The Multiple Capacitated Facility Location Problem (MCFLP) is a well-known and studied in the international literature optimization problem. A web-based Decision Support System (DSS) for this problem is being implemented. The geographical information data of the enterprises' locations are usually either ignored by the modeler or entered manually in these systems. In this paper, we integrate geographical data in the DSS for the MCFLP. The location of the enterprises can be added with the use of interactive maps. The DSS extracts the geographical information of the selected locations and executes a dynamic approximation algorithm for this problem. The web-based spatial DSS (WSDSS) has been implemented using jsp and Google Maps API; the system is still under development, but initial results are promising.

Keywords: Decision Support System, Capacitated Facility Location Problem, Geographical Information System, Location Allocation Problem.

1 Introduction

The facility location (or location-allocation) problem is a well-known operations research problem. The problem consists of a number of enterprises that attempt to find the best location in a specific area in order to install their new facilities while on the same time a number of already established similar facilities exist with known locations [1 – 2]. New enterprises seek the best location from a set of candidate locations in order to maximize their share and revenue in the specific market. The new enterprises cooperate with each other in order to avoid any overlapping between the market segments they will serve. The facility location problem has many practical applications in different fields [3 – 6].

The international research community offered many variants and extensions of the problem over the years; in this paper, we consider a particular type of the problem, called the Multiple Capacitated Facility Location Problem (MCFLP). In this version of the problem, the market requires a specific quantity/level of a product/service in a determined time period. A set of existing enterprises operate in a specific market producing/offering certain products/services. A set of new cooperating enterprises aim to enter the market and seek the best location from the available candidate locations. The goal of the new enterprises is to obtain the largest possible share of the specific, saturated by the present supply, market by avoiding on the same time any overlapping between the market segments that they will serve. The enterprises should be economically viable in order to enter the market. As such, the production of a new enterprise should be higher than a specified sales threshold level [7]. Existing enterprises should also ensure to be economically viable; if they fail to reach their production thresholds after the entering of the new enterprises, they will be taken off the map [8].

Only few software packages exist for the solution of this problem exclusively. The geographical information of the enterprises' locations are usually either ignored or entered manually in these systems. Geographical information systems (GIS) can assist decision makers to analyze spatial information. GIS technologies have attracted significant attention from researchers. There are a few papers proposed integration of GIS technologies on DSS for location problems [9 – 10]. Google Maps API provides access to read data associated with roads and supplies travel times for each road based on the speed limits. The Google Maps API is a promising technology for implementing a web-based DSS for the facility location problem.

This paper is an extension of the work of Papathanasiou et al. [11], in which we presented a web-based DSS that can assist policy makers find the best locations for their enterprises. Two algorithms were integrated in the DSS: (i) an algorithm that finds the exact solution of the problem so long as this exists, and (ii) a dynamic approximation algorithm that can calculate an approximation solution in an acceptable time interval. These algorithms have been proposed by Papathanasiou and Manos [12]. The innovation of this paper is that we integrate geographical information data in the DSS for the MCLP. The coordinates of the locations are not entered manually in imaginary vague market, but they are added with the use of an interactive map. Then, the DSS extracts the coordinates of these locations and builds a market surface, which is simulated by a network with existing facilities nodes, demand nodes and candidate nodes. The DSS was implemented using jsp and Google Maps API and is still under heavy development and testing.

2 Model Specification and Algorithms

The mathematical form of the problem described in Section 1 can be formulated as follows [11]:

$$\max \sum_i \sum_p DP_{ip} X_i \tag{1}$$

or

$$\max \sum_i \sum_p aDP_{ip} Q_{ip} X_i \tag{2}$$

s.t.

$$DP_{ip\min} \leq DP_{ip} \leq DP_{ip\max} \tag{3}$$

$$\sum_i X_i = P \tag{4}$$

$$Y_{ij} - X_i \leq 0 \tag{5}$$

$$X_i = 0,1 \tag{6}$$

$$Y_{ij} = 0,1 \tag{7}$$

$$UP_{ij} = 0,1 \tag{8}$$

$$UM_{mj} = 0,1 \tag{9}$$

$$\sum_p DP_{ip} = \sum_p \sum_i \sum_j H_{ij}^p Y_{ij} UP_{ij} \tag{10}$$

where:

|P|: the cardinality number of new enterprises

$p_n \in P = \{p_1, p_2, ..., p_k\}, n = 1, 2, ..., k$

|M|: the cardinality number of existing enterprises

$m_f \in M = \{m_1, m_2, ..., m_k\}, f = 1, 2, ..., h$

|I|: the cardinality number of candidate nodes of new enterprises

$i_s \in I = \{i_1, i_2, ..., i_q\}, s = 1, 2, ..., q$

|J|: the cardinality number of demand nodes

$j_r \in J = \{j_1, j_2, ..., j_b\}, r = 1, 2, ..., b$

T: the time within which the market demands a specific quantity of the product in question

DP_{ip}: the production capacity in time T of the new enterprise p established in node i

DP_{ipmax}: the maximum production capacity in time T of the new enterprise p established in node i

DP_{ipmin}: the minimum acceptable production capacity in time T of the new enterprise p established in node i

DM_m: the production capacity in time T of the existing enterprise m

DM_{mmax}: the maximum production capacity in time T of the existing enterprise m

DM_{mmin}: the minimum acceptable production capacity in time T of the existing enterprise m

H_j: demand in demand node j

HP_{ij}^p : the fraction of demand in node j, which is serviced by node i where the new enterprise p has been located

HM_{mj}: the fraction of demand in node j where the existing enterprise m has been located

S_{pi}: the range of new enterprise p in node i and in time T (distance units)

S_m: the range of existing enterprise m in time T (distance units)

Q_{ip}: the production cost of new enterprise p in node i.

Q_m: the production cost of existing enterprise m.

a: the profit percentage.

The total number of nodes of the network is |I|+|J|+|M|. Objective functions (1) and (2) refers to the maximization of the product that was produced, in the event that the cooperating enterprises choose the aggressive and the conservative tactic, respectively.

Constraint (3) refers to the range of prices which the quantity of production can obtain for each p_n within the given time T, while constraint (4) requires that precise |P| enterprises are established. Constraint (5) allows the service only from nodes where units have been established and constraints (6) – (9) require that the these variables are integers to the values of zero and one. Finally, constraint (10) shows that each new enterprise's entire production is consumed; otherwise surplus stock of unsold products will be created.

The multiple capacitated facility location problem is NP-hard [13] and the algorithms that have been proposed to find the optimal solution use the Lagrangean relaxation method as the core technique or transportation simplex method. Hence, the execution time of an exact algorithm is prohibited for inclusion in a web-based spatial DSS.

For the solution of the above model, two algorithms are used in this paper [11]: (i) an algorithm that finds the exact solution of the problem so long as this exists, and (ii) a dynamic approximation algorithm that can calculate an approximation solution in an acceptable time interval (for a more detailed description, see [11 – 12]).

3 Integrating Geographical Information Systems

The locations of the candidate nodes are usually entered manually. Many DSS for the facility location problem simulate the market segment as a graph and the distances between the nodes are not always corresponding to the real situation. The DSS that we presented in [10] used the same rationale (Fig. 1). The main aim of this paper is to discuss implementation issues of a web based Spatial DSS that uses freely available Google Maps to integrate GIS technologies on the MCFLP.

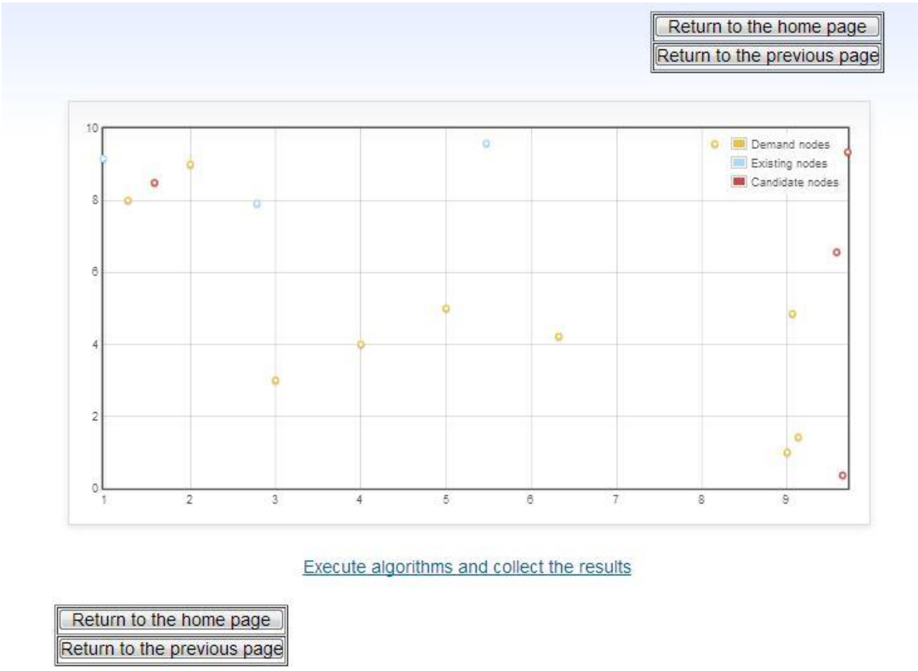

Fig. 1. Market Representation for the MCFLP

In Fig. 1, a visual representation of the WSDSS in terms of a flow chart is represented. Initially, the decision maker selects the locations of the candidate nodes and the existing enterprises via an interactive Google Map. The locations of the candidate nodes are added interactively in a Google Map, as shown in Fig. 3. Then, the other parameters of the model can be entered though user-friendly interactive forms. In the next step, the algorithms are executed and a solution is constructed. If a solution is found, then it is visually displayed through the use of a Google Map instance.

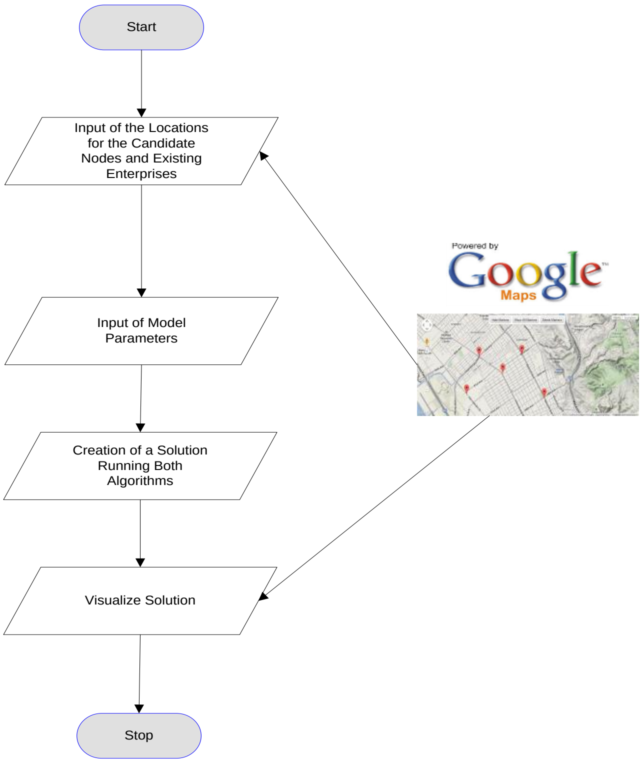

Fig. 2. Flow Chart of the WSDSS

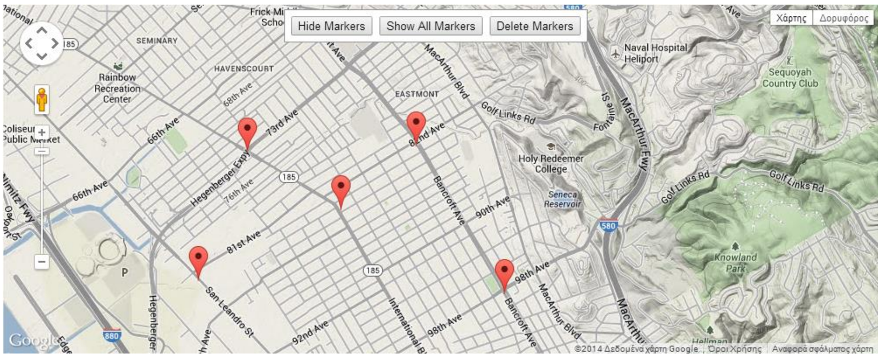

Fig. 3. Adding Locations of the Candidate Nodes via an Interactive Map

4 Conclusions

The MCFLP is a well-known operations research problem with many practical applications. GIS technologies have not yet been integrated extensively on web-based DSS for this specific problem. In this paper, we discuss implementation issues for integrating GIS technologies on a web-based spatial DSS still under development. The decision maker can easily add the candidate locations through an interactive Google Map. Then, the DSS can export the geographical coordinates and the time distances from the specified locations and execute the optimization algorithms.

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A Chief Technical Officer Selection using Extent Analysis Method

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Abstract. Today, Chief Technical Officer (CTO) selection is an important position in every company where information and communication technologies have a huge impact on a company's development. The complexity and importance of the problem, call for analytical methods rather than intuitive decisions. This selection as a subset of personnel selection contains different characteristics compared to a selection of other personnel. The multi-criteria nature and the presence of both qualitative and quantitative factors make it considerably more complex. This paper proposes a CTO selection approach based on the fuzzy extent analysis method which is applied in a real-life case study to evaluate the most suitable person for a CTO position in a company dealing with the rating of both qualitative and quantitative criteria.

Keywords: CTO selection, fuzzy numbers, extent analysis method.

1 Introduction

With an increasing number of organizations exploiting information technology in innovative ways, many companies have been adding a Chief Technology Officer (CTO) to their executive leadership teams. Essentially, the CTO role is polymorphic: it either assesses the use of an existing technology or developing a new platform, which impacts an organization in improving its competitive performance within a given industry.

CTO selection is a very important activity for Human Resources Management (HRM) that requires adequate selection criteria. When candidates apply for CTO positions in a company, the basic purpose of selection operations is to determine those that have the necessary up-to-date knowledge, business experience, technical performance, and language skills. As such, the CTO selection is a multi-criteria decision making problem which is affected by several qualitative and quantitative, often conflicting criteria. In many situations of human resources selection, individuals from the Human Resources Department (HRD) mostly prefer to express their feelings with verbal expression. Fuzzy linguistic models permit the translation of verbal expressions into numerical values. For that reason, these models can help to HRD in solving CTO selection problem. For personnel selection, fuzzy set theory has been proposed by Miller and Feinzing [1], Karsak [2] and Capaldo and Zollo [3].

This paper describes a fuzzy method for CTO selection which was proposed by Chang [4]. The method is known as an extended analytical method. The rest of the paper is structured as follows: in Section 2 an introduction of fuzzy sets and fuzzy numbers is given. Section 3 explains the steps of extent analysis method. Section 4 analyzes the real-life problem of selecting CTO by using extent analysis method. The obtained results are discussed in this Section, too. Finally, the paper concludes with Section 5 where the conclusive considerations are presented.

2 Fuzzy set theory and fuzzy numbers

Fuzzy set theory was introduced by Zadeh as an efficient way to mathematically represent uncertain and imprecise human assessments which are generally characterized for its linguistic terms that are based on words such as “equally”, “moderately”, “strong”, “very strong” and “exceptional” [5] and [6]. Apart from the cited author, this topic was analyzed in many other studies. Fuzzy sets generally employ triangular, trapezoidal and Gaussian fuzzy numbers, converting uncertain numbers into fuzzy numbers. To solve the problem of CTO selection in this paper will be used triangular fuzzy numbers according to following definition:

Definition. A triangular fuzzy number is denoted simply by a triplet *(l|m, m|u)* or *(l, m, u)*. The parameters l, m and u, respectively, define the smallest possible value, the most promising value and the largest possible value that describes a fuzzy event. The triangular type membership function of $\tilde{M}$ fuzzy number can be described as Eq. (1) [7] and [8]:

$$\mu(x|\tilde{M}) = \begin{cases} 0, & x < l \\ \frac{x-l}{m-l}, & l \le x \le m \\ \frac{u-x}{u-m}, & m \le x \le u \\ 0, & x > u \end{cases} \tag{1}$$

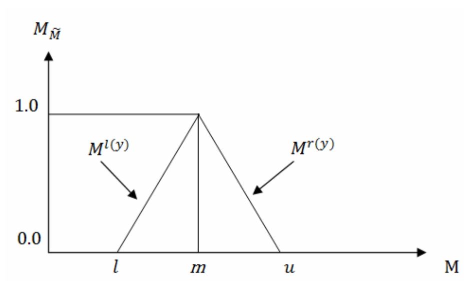

Fig. 1. Triangular fuzzy number M

Commonly triangular fuzzy numbers are displayed with the usage of the linguistically significance scale, shown in Table 1 [9] and [10].

Table 1. Linguistic scale of importance.

Linguistic scale of importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equal	(1,1,1)	(1,1,1)
Weak	(1/2,1,3/2)	(2/3,1,2)
Fairly strong	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strong	(5/2,3,7/2)	(2/7,1/3,2/5)
Absolute	(7/2,4,9/2)	(2/9,1/4,2/7)

Available reading and texts offer numerous methods of gradation by means of fuzzy numbers. Such methods may yield different gradation results and require complex mathematical calculations. One of the useful methods which use to solve multicriteria decision-making problems based on fuzzy numbers is an extent analysis method. This method is used to consider the extent of an object to be satisfied for the goal, that is, satisfied extent. In the method, the ''extent'' is quantified by using a fuzzy number.

Let $X = \{x_1, x_2, ..., x_n\}$ be an object set and $G = \{g_1, g_2, ..., g_m\}$ be a goal set. According to the method of Chang extent analysis [12], each object is taken and extensive analysis for each goal g_i is performed, respectively. Therefore, *m* extent analysis values for each object can be obtained as $M_{g_i}^1, M_{g_i}^2, ..., M_{g_i}^m$, *i=1,2,..n*. All of the $M_{g_i}^j$, *j=1,2,..,m* are the triangular fuzzy number. The steps of Chang's extent analysis are:

Step 1: The value of fuzzy synthetic extent with respect to the i^{th} object is defined as Eq. (1):

$$S_i = \sum_{j=1}^{n} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \tag{2}$$

To obtain $\sum_{j=1}^{n} M_{g_i}^j$ it is necessary to perform the fuzzy addition of numbers in the matrix such that $\sum_{j=1}^{n} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$ and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1}$ which is performed by using the operation of fuzzy addition of all values such that $M_{g_i}^j$, *j=1,2,..,m* $\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right)$ (3)

The vector from Eq. (2) is determined in Eq. (4):

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{4}$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2)$ and $M_1 = (l_1, m_1, u_1)$ is defined in Eq. (5):

$$V(M_2 \geq M_1) = y \geq x\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \tag{5}$$

and can be equivalently expressed as follows Eq. (6):

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \\ = \mu_{M_2}(d) = \begin{cases} 1, & if \quad m_2 \geq m_1 \\ 0, & if \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & other \end{cases} \tag{6}$$

where *d* is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i, *i=1,2,..,k* can be defined by Eq. (7):

$$V(M \geq M_1, M_2, ..., M_k) = \min V(M \geq M_i), \; i=1,2,..,k \tag{7}$$

Assume that $d'(A_i) = \min V(S_i \geq S_k), k \neq i$, *k=1,2,..,n* (8)

and then the weight vector is given as

$$W' = \left(d'(A_1), d'(A_2), ..., d'(A_n)\right)^T \tag{9}$$

where A_i, i=1,2,..,n is a matrix with n elements.

Step 4: Via normalization, the normalized weight vectors is given by Eq. (10):

$$W = \left(d(A_1), d(A_2), ..., d(A_n)\right)^T \tag{10}$$

where *W* is a non-fuzzy number [11].

3 Application of fuzzy extent analysis method for CTO selection

Select a suitable CTO is a success critical factor for IT management in every company. Companies with appropriate CTO people are able to build internal relationships between the Information Systems function and other departments of the firm, leading to integrated planning processes at the corporate level and manage relationships between the Information Systems function and stakeholders outside the company. At the same time, with suitable CTO, companies can anticipate future business needs of the company and make innovation of valuable new product features before competitors and in parallel manage effectively the resulting technological change and growth [12]. There are the main reasons why CTO selection is very important in every company.

A multinational telecommunication company needs to hire a person for CTO position. After preliminary screening, three candidates, namely CTO1, CTO2 and CTO3 remain for further evaluation. A committee of three decision-makers (DM1, DM2 and DM3) from HRD has been formed to conduct the interview and to select the most suitable candidate. A committee considered three selection criteria and eight sub-criteria in according to the requirements of the DM's and relate to the specific job description: Personnel Characteristics (PC), Business Factors (BF), Technical Competencies (TC), Self-Confidence (SC), Foreign Language (FL), Education Background (EB), Business Experience (BE), Leadership (LS), Team Working (TW), Technical Certificates (TCF) and Project Management Knowledge (PMK). The hierarchical tree is given in Fig. 2.

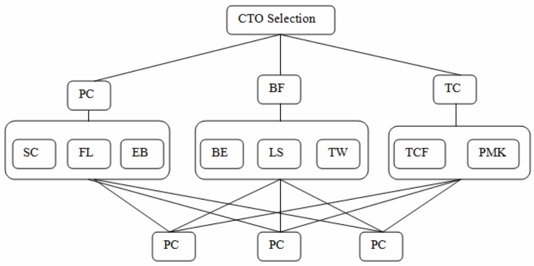

Fig. 2. The hierarchical tree of CTO selection problem

Priority weights of each criterion, sub-criterion and CTO are calculated by means of fuzzy extent analysis method. The ratings of the three CTOs by the committee for from HRD (expressed in fuzzy numbers) under all criteria are given in Table 2.

Table 2. The ratings of the three CTOs by committee under all criteria.

Decision maker	Criteria	PC	BF	TC
DM1	PC	Equal	Fairly strong	Very strong
	BF	Fairly strong	Equal	Weak
	TC	Very strong	Weak	Equal
DM2	PC	Equal	Equal	Fairly strong
	BF	Weak	Equal	Fairly strong
	TC	Fairly strong	Fairly strong	Equal
DM3	PC	Weak	Weak	Fairly strong
	BF	Weak	Weak	Fairly strong
	TC	Fairly strong	Fairly strong	Equal

Priority weights of each criterion, sub-criterion and CTO are calculated by means of fuzzy extent analysis method and obtained results is given in Table 4, Table 5 and Table 6.

Table 4. The priority weights for criteria and sub-criteria.

Criterion	Aggregated Weight	Sub-criterion	DM1	DM2	DM3
		SC	0,2643	0,3606	0,1450
PC	0,0712	FL	0,3148	0,2135	0,3229
		EB	0,4209	0,4259	0,5321
		BE	0,3333	0,3333	0,3333
BF	0,2880	LS	0,3333	0,3333	0,3333
		TW	0,3333	0,3333	0,3333
TC	0,6408	TCF	0,5000	0,5000	0,0000
		PMK	0,5000	0,5000	1,0000

Table 5. The priority weights of the CTOs for each decision maker from committee.

Criterion	Sub-criterion	CTO	DM1	DM2	DM3
	SC	CTO1	0,2630	0,3333	0,1757
		CTO2	0,4119	0,3333	0,5219
		CTO3	0,3251	0,3333	0,3023
PC	FL	CTO1	0,4119	0,4119	0,4209
		CTO2	0,3251	0,3251	0,3148
		CTO3	0,2630	0,2630	0,2643
	EB	CTO1	0,3333	0,2392	0,3333
		CTO2	0,3333	0,4192	0,3333
		CTO3	0,3333	0,3416	0,3333
	BE	CTO1	0,1700	0,1700	0,1102
		CTO2	0,8300	0,8300	0,8898
		CTO3	0,0000	0,0000	0,0000
BF	LS	CTO1	0,3251	0,1569	0,3416
		CTO2	0,4119	0,6142	0,4129
		CTO3	0,2630	0,2289	0,2392
	TW	CTO1	0,0420	0,3220	0,2289
		CTO2	0,9580	0,4950	0,6142
		CTO3	0,0000	0,1830	0,1569
TC	TCF	CTO1	0,5619	0,5619	0,4572
		CTO2	0,4381	0,4381	0,4572
		CTO3	0,0000	0,0000	0,0857
	PMK	CTO1	0,3333	0,3333	0,3333
		CTO2	0,3333	0,3333	0,3333
		CTO3	0,3333	0,3333	0,3333

Table 6. Global weights of the CTO with respect to the objective for each decision maker

CTO	DM1	DM2	DM3	Aggregated Weight
CTO1	0,3210	0,4476	0,2892	0,3526
CTO2	0,5380	0,3857	0,4689	0,4642
CTO3	0,1320	0,1667	0,2419	0,1820

It has been determined that the aggregate CTOs weights are (0.3526, 0.4642 and 0.1820). According to the final result, the most suitable candidate for CTO is CTO2 with the highest priority weight. If we consider obtained results from Table 4, we can conclude the following: for decision makers from HRD very important criterion for CTO selection is Technical Capabilities with priority weight 0.64. It is a logical fact, because CTO should to be ''technical person'' who responsible for information technology development in the company. For that reason, the CTO2 has got very high weights for TC criterion from all decision makers (see Table 5). At the same time, the CTO2 has a huge business experience which in combination with Technical Knowledge guarantee that the committee made the best choice.

At this place, we need to emphasize that the CTO selection problem is extremely complex in real life because humans generally fail to make a good prediction for quantitative problems, in contrast, they may make accurate guesses in qualitative forecasting [13]. The CTO selection problem generally concerns with important and complex issues such as: (i) How to properly set the importance weights of criteria to reflect the situations in which not all personnel attributes/characteristics are equally important? (ii) How to use linguistic and/or numerical scales to evaluate the applicants under multiple criteria? (iii) How to aggregate the evaluation results and then rank the applicants? The inherent importance and complexity of the CTO selection problem as a subset of personnel selection problem require effective analytical methods to provide an operational/tactical decision framework [14].

In this paper, we proposed a specific kind of analytical method called fuzzy extent analysis method. This method gives a solution for previous issues. This method allows mathematical calculation criteria weights which lead to reduce the subjective judgments in the process of distinguishing between an appropriate and inappropriate employee for a job position. For this reason, many decision makers from HRD in Serbian companies are very satisfied with the proposed method.

4 Conclusion

Selecting the most suitable CTO person is a key success factor for an organization. With appropriate CTO people, companies are able to build internal relationships between the Information Systems function and other departments of the firm. It leads to integrated planning processes at the corporate level and manage relationships between the Information Systems function and stakeholders outside the company. The complexity and importance of the problem, call for analytical methods rather than intuitive decisions. The specificity of this problem consists in dealing with imprecise data, difficulties in retrieving information and expressing an explicit opinion. CTO selection is a process that also contains uncertainties. The decision makers face rising and complex environments today, and also decision makers are often uncertain in assigning the evaluation scores in crisp value. This problem can be overcome by using fuzzy numbers and linguistic variables to achieve accuracy and consistency. Fuzzy logic is considered ideal to deal with this type of problems.

In this paper, we tried to involve the fuzzy extent analysis method in the process of selecting the most suitable CTO. Unlike other decision methods, the described method can adaptively find a suitable CTO for the required job. For making uniform consensus of the decision makers, we converted all pairwise comparisons into triangular fuzzy numbers to adjust fuzzy rating and fuzzy attributes weight, and used fuzzy operators to get to select the best alternative.

In the future research, the authors suggest developing electronic fuzzy decision support system as a help tool for CTO selection which will give possibilities for automatic calculations all results from Tables given in this paper.

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A fuzzy Decision Support System for Bidder Selection in Public Procurement

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Abstract. The bidder selection in public procurement can be viewed from the perspective of decision making problems, where selection of the most acceptable bid, in fact, represents the objective of a decision making problem. This selection is based on many alternatives and many quantitative and qualitative criteria where qualitative criteria often expressed as linguistic uncertain variables. The theory of fuzzy sets has demonstrated suitable to model uncertainty when applied to a variety of problems in science and real life. However, many fuzzy methodologies require complex calculation and, as such, they aren't appropriate for using in public procurement because they slow down this process. In this paper, in order to make a quick decision in uncertain situations in public procurement, a specific Decision Support System is developed. The system is based on the fuzzy extent analysis method and applied to bidder selection in a real-life case of public procurement in Serbia.

Keywords: public procurement, bidder selection, fuzzy numbers, Decision Support System.

1 Introduction

Public procurement means the procurement of goods, services and work by the government authority, in the manner and under conditions prescribed by the Law of public procurement in Serbia [1]. The one of very important phase in public procurement is bidding evaluation and selection of the most acceptable bid. The specific characteristic of public procurement is that this process must comply with specific legislative requirements. For instance, in Serbia, public procurement is regulated by the Public Procurement Law, which sets the application of one of the two following criteria for evaluating bids in public procurement processes: the Lowest Price offered and the Most Economically Advantageous Bid (MEAB).

Depending on the subject of public procurement The MEAB criterion is based on various elements of the criterion (price, quality, references, time delivery, etc.). The selection and evaluation bids based on MEAB criterion can be viewed from the perspective of the decision making phenomenon, where selection of the most acceptable bid, in fact, represents the objective of a decision making problem based on many alternatives and criteria. Alternatives are the bids or bidders who possess specific resources that they wish to place in the service of satisfying the purchaser's needs. Criteria are attributes for describing offered bids and they indicate the extent to which individual bids realize the set objective of public procurement.

In many practical cases of public procurement we have qualitative criteria which are described as linguistic variables. In practical usage of public procurement software, we can't compare qualitative criteria (quality, technical performance, etc.) to quantitative criteria (price, time delivery, references, etc.). For example, public procurement software from reference [2], [3] and [4] don't have possibilities to compare qualitative and quantitative criteria. In all cases, this software uses the Linear Weighting Technique for selecting the MEAB in the public procurement. Current public procurement platform in Serbia doesn't have functionality for bidder selection and contract award [5].

When we have qualitative criteria in public procurement, we can use fuzzy set theory which was introduced by [6] and [7] as an efficient way to mathematically represent uncertain and imprecise human assessments. Various fuzzy methods have been described in many studies [8], [9] and [10]. However, many proposed fuzzy methodologies require complex and huge calculation. As such, these methodologies aren't appropriate for using in public procurement processes because they slow down this process. In order to help with public procurement committee make a quick and good decision which is based on MEAB criterion in uncertain situations, a fuzzy Decision Support System is proposed in this paper.

The rest of this paper is organized as follows: Section 2 covers short explanation of the fuzzy set theory and fuzzy extent analysis method. This section also gives a short description of DSS design which is based on the fuzzy extent analysis method. In Section 3, fuzzy DSS is applied in order to solve the problem of selecting the most appropriate DATA Storage Hardware System bidder in one public procurement process in Serbia. The work is rounded up with conclusive remarks in Section 4.

2 Design and Development of Fuzzy DSS

The fuzzy DSS, which is described in this section, uses triangular fuzzy numbers as in the following studies [11], [12] and [13]. Commonly triangular fuzzy numbers are displayed with the usage of the linguistically significance scale, shown in [14] and [15]. Proposed fuzzy DSS based on the extensive analysis method, described in [15]. This method was widely used in many studies, e.g. [16], [17] and [18] and so, no detailed explanation of it will be provided here.

Shortly, this method may be summarized as follows: defining membership function for each criterion and eventually sub-criterion, calculating their degrees of membership and applying the fuzzy Analytical Hierarchy Process to the weight aggregation.

Using these steps of extent analysis method and using JAVA technology, a fuzzy DSS based on fuzzy triangular numbers is developed.

Fig 1 shows a UML class diagram of developed fuzzy DSS. Basic elements of this module are classes *Criteria* and *Alternative*. They are generalized from abstract class Element. Class *FuzzyNumber* represent a triangular fuzzy number. Classes Degree, *SyntheticExtent, Result* and *FinalResult* help classes for calculation of fuzzy AHP. *Calculate* is an abstract class which represents the template method software pattern. It is generalized to classes *FuzzyAHP* and *ChangFuzzyAHP*. Because of this template method, this software module can be extended with new methods, not only fuzzy AHP's, but methods like fuzzy TOPSIS or any other method that requires pairwise comparison of each pair of factors in the same hierarchy level. *Util* class is a singleton that provides a single point of access to this module.

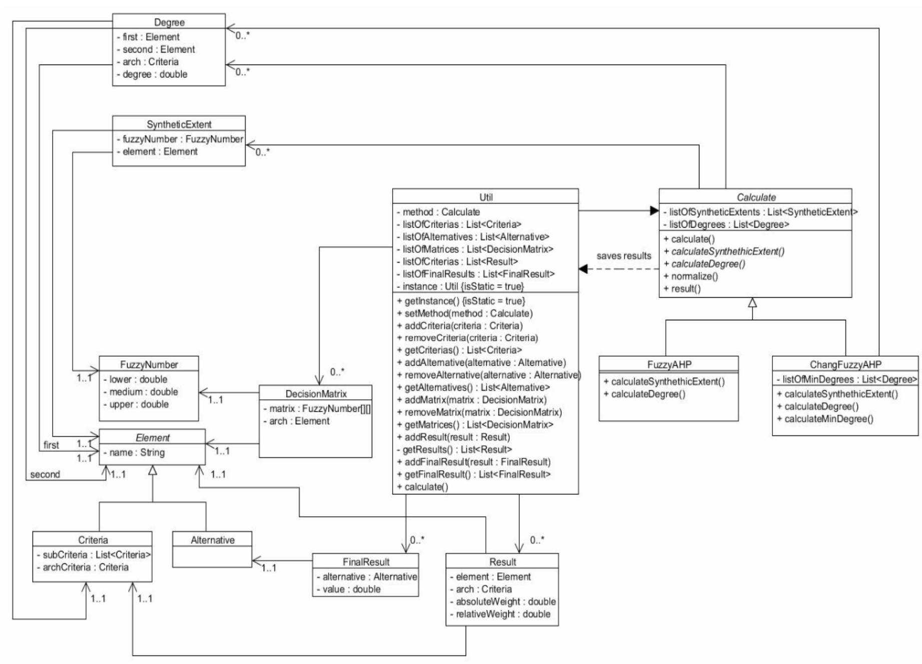

Fig. 1. The class diagram of fuzzy DSS.

This DSS is created to help public procurement committee make quick and good decision for bidder selection in the public procurement process. In the next section, the application of the proposed DSS on a real life problem is given.

3 Application of fuzzy DSS for bidder selection – case study

A government institution (contract authority) in Serbia created a call for public procurement of Data Storage Hardware System for Big Data. The Data Storage Hardware System is a complex system for recording (storing) information (usually Big Data). Big Data commonly refers to the management and processing capabilities of huge amounts of data, from hundreds of terabytes and above.

After the public opening of the bids, the public procurement committee selected three bidders (B_1, B_2 and B_3) who met the legal requirements for participation in public procurement. Evaluation and selection of the most economically advantageous bidder among these three bidders is based on following criteria: Technical Features (TF), Payment Terms (PT), the Product Price (PP) and Time Delivery (TD). These criteria have been determined in cooperation with technical experts from the government Computer Department.

Priority weights for each criterion and bidder are calculated by means of a fuzzy extent analysis method using the proposed DSS. The ratings of the three bidders by technical experts under all criteria are given in Table 1.

Table 1. The ratings of the three bidders by technical experts under all criteria.

Criterion	TF	PT	PP	TD
TF	Equal	Fairly strong	Weak	Very strong
PT	Fairly strong	Equal	Fairly strong	Weak
PP	Weak	Fairly strong	Equal	Fairly strong
TD	Very strong	Weak	Fairly strong	Equal

Using data from Table 2 in [15], linguistic variables from Table 1 can be converted to triangular fuzzy numbers.

Table 2. Linguistic scale of importance.

Linguistic scale of importance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equal	(1,1,1)	(1,1,1)
Weak	(1/2,1,3/2)	(2/3,1,2)
Fairly strong	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strong	(5/2,3,7/2)	(2/7,1/3,2/5)
Absolute	(7/2,4,9/2)	(2/9.1/4,2/7)

The fuzzy DSS uses triangular fuzzy numbers (see Fig.2) and automatically calculates final results (see Fig. 3 and 4).

From Fig. 3 we can see that the most important criterion for bidder selection here is Technical Features as it has the highest priority vector (0,460). This criterion is followed by Product Price (0,394), Time Delivery (0,083) and then Payment Terms (0,062).

At the same time, if we consider the results from Fig. 4 we can conclude that the most suitable bidder is B_2 with the highest priority weight (0,421).

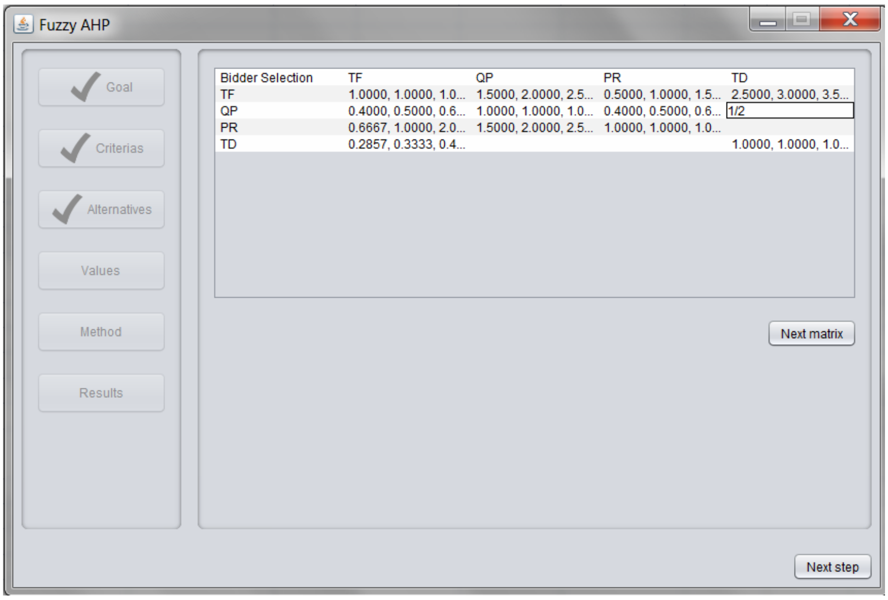

Fig. 2. Creation of fuzzy matrix of criteria comparison.

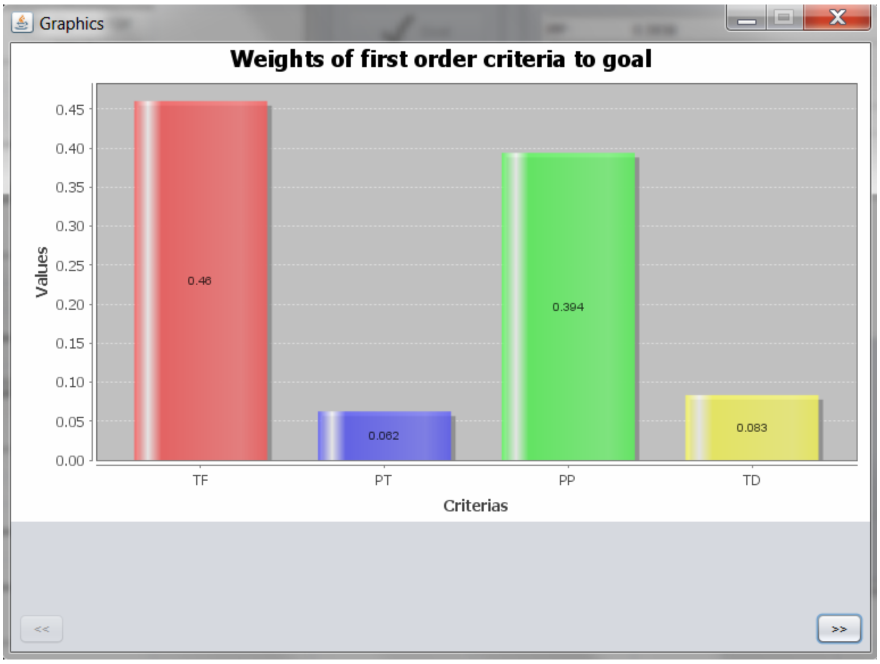

Fig. 3. The results from fuzzy DSS: weights of criteria.

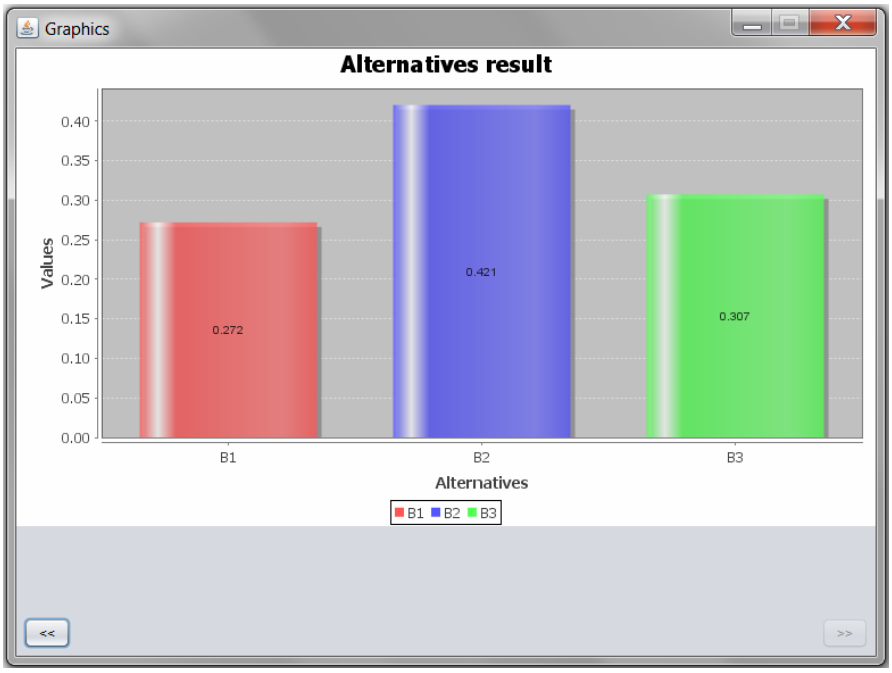

Fig. 4. The results from fuzzy DSS: rank of bidders.

According to the final results from Fig. 4, the most suitable bidder is B_2 with the highest priority weight (0.421). If we consider obtained results from Fig. 3, we can conclude the following: for public procurement committee very important criterion for bidder selection is Technical Features with priority weight 0.46. It is expected result because Data Storage System should have excellent technical characteristics for secure storing of data.

This case study shows how the whole public procurement process became more precise and shorter by using of this DSS. It is very important, take in consideration the fact that public procurement process in according to Law [1] must to be more efficient and more economically. In comparison to other DSS in public procurement, like software from reference [2], [3] and [4] we can conclude that the proposed fuzzy DSS give possibilities to include qualitative criteria in bidder evaluation. It's not case with other public procurement DSS. In addition, usage of this system makes easier bidder evaluation because this DSS makes the automatic fuzzy calculation and ranks bidders automatically. All that is required by the public procurement committee is entering input data (decision maker's preferences) which is converted to fuzzy numbers.

For mentioned reasons, the government authorities have motivation for using this DSS because it eliminates huge and complex calculation in comparison with manual calculation which is usual in current procurement processes.

4 Conclusion

A good bidder selection in the public procurement process is a strategic decision of all governments which provides economical, transparent and non-discriminatory work of every government authority. In his nature, bidder selection in public procurement is multi-criteria decision problem where are many alternatives (bidders) and criteria (quantitative and qualitative) existing.

In many practical cases of public procurement we have qualitative criteria which are described as linguistic variables. The existing public procurement software doesn't have possibilities to compare qualitative and quantitative criteria. In all cases, this software uses the Linear Weighting technique for selecting the MEAB in the public procurement. Because we have qualitative criteria expressed in linguistic variables, we can use fuzzy set theory as an efficient way to mathematically represent uncertain and imprecise human assessments.

In order to support the public procurement committee to make a quick and good decision which is based on MEAB criterion in uncertain situations the fuzzy DSS is developed in this study. This paper has shown the practical usage of DSS to make bidder selection in one real-life case study of public procurement in Serbia. In this case study, we saw that public procurement committee need to enter own preferences in fuzzy DSS. It's everything what does public procurement committee. The proposed fuzzy DSS automatically calculates priority weights of criteria and sub-criteria and automatically ranks bidders.

Future research shall be dedicated to involving this fuzzy DSS into an electronic public procurement platform in Serbia as national web portal for public procurement.

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PART VI

Conflict Resolution

Misperception of Preferences in the Graph Model for Conflict Resolution

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Abstract. The Graph Model for Conflict Resolution is modified to model misperception of preferences by decision makers (DMs) in a conflict. DMs' relative preferences are represented by pairwise comparisons of possible states in a conflict. A two step procedure is presented to ascertain equilibria of the modified graph model. The Cuban Missile Crisis is utilized to illustrate the applicability of the modified graph model approach.

Key words: hypergame, preferences, misperception, modified graph model

1 Introduction

A conflict is a condition in which there is a situation of opposition and parties with contrasting goals affect each other [1],[2],[3],[4],[5]. A number of approaches have been proposed to model real world disputes such as metagame analysis [6], conflict analysis [1], and the Graph Model for Conflict Resolution (GMCR) [2],[7],[8]. GMCR is capable of graphically representing all the possible moves and countermoves among decision makers (DMs), and can predict possible compromise resolutions for the conflict by using a range of solution concepts [9], [10], [11], [12]. A common feature of all of the aforementioned approaches is that they can represent and analyze any real world dispute under the assumption of complete information.

2 Background

This research considers a conflict model involving incomplete information, namely, a hypergame [13]. This approach allows one to model any dispute based on the way a certain DM views the situation of the conflict; as a result, different perceptions among DMs are developed, different games are played, and different resolutions are reached. The notion of the hypergame goes back to [13], [14] in which a general model for the theory of hypergames was established. Subsequently, Wang et al. [15] enhanced the theory of hypergames by developing a clear mathematical model and practical processes for conducting the individual stability analysis and the group equilibria. Furthermore, Wang et al. [16] presented a comprehensive development of the theory of hypergames. The goal of this paper is to develop an approach for modeling and analyzing misperception of preferences by DMs within the GMCR framework. In particular, the first level hypergame involving misperception of preferences is considered.

3 Modified Graph Model for Modeling Misperception of Preferences

The present work addresses the simplest class of the first level hypergame, which is misperception of preferences by DMs [16]. In this situation, one or more of the DMs misperceive other DMs' preferences. Other components of the game such as options, strategies, and the set of feasible states are not susceptible to any misperception.

Fig. 1 shows the procedure for forming the modified graph model incorporating consideration of preference misperception. As can be seen, the first four steps are the same as the ones used in the standard graph model [2],[7],[8]. However, Step 5, in which the DMs' relative preferences are obtained, is modified to handle the way each DM views his or her opponents' preferences. Without loss of generality, it is assumed in this paper that all DMs correctly view their own preferences, and the set of the states are defined by using the option form [1],[2].

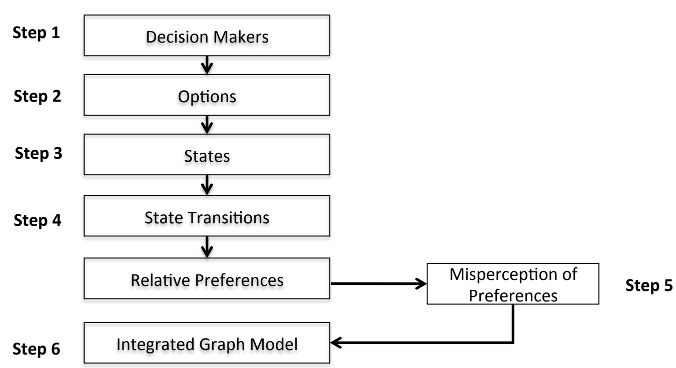


Fig. 1. Modified graph model for modeling misperception of preferences

3.1 Formal Definitions

A 2-DM modified graph model that can model misperception about preferences can be represented by individual games as expressed in Eq. (1); moreover, it can also be described by a 4-tuple as shown in Eq. (2):

$$\hat{G} = \{\hat{G}_k, k \in N\} \tag{1}$$

$$\hat{G}_k = \{N, S, \{\succeq_i^k, \succeq_j^k\}, \{A_i, A_j\}\} \tag{2}$$

The notations are explained as follows. $\hat{G}_k$ is the game perceived by DM_k, $k \in N$. $N = \{i, j\}$ is the set of DMs. S is a non-empty, finite set, called the set of feasible states, which denotes the vertex set. The binary relationship $\succeq_i^k$ is DM_i's preference as perceived by DM_k. Similarly, $\succeq_j^k$ is DM_j's preference as perceived by DM_k. Finally, for each $DM_k \in N, A_k \subseteq S \times S = \{(s_1, s_2) \in S\}$ is DM_k's set of directed arcs, which contains the movements in one step controlled by DM_k.

The preference relationships for the modified graph model share the same properties as those of the standard graph model [2]; on the other hand, they do not share the same properties as those of theory of hypergames [16]. That is, the modified graph model uses pairwise comparisons to represent DMs' preferences and as a result, is able to handle both transitive and intransitive preferences. However, the theory of hypergame represents DMs' preferences by ordinal ranking, and as a result, can only handle transitive preferences. The preference relationships for the modified graph model are defined below for DM_j as seen by DM_k.

For any given $DM_k \in N$, a preference structure over the set of states can be represented by a pairwise comparison between any two states. A complete and reflexive weak preference relationship ($\succeq_j^k$) consists of two binary relationships $\{\succ_j^k, \sim_j^k\}$. For any pair of states s and $q \in S$, DM_j strictly prefers q over s as perceived by DM_k $q \succ_j^k s$ if and only if (iff) $q \succeq_j^k s$, but not $s \succeq_j^k q$. However, if DM_j is indifferent between s and q as perceived by DM_k $s \sim_j^k q$, then $s \succeq_j^k q$, and $q \succeq_j^k s$ must be true. It is assumed that, $\{\succ_j^k, \sim_j^k\}$ is strongly complete; i.e., for any s, $q \in S$, at least one of the following conditions is true: $s \succ_j^k q$, $q \succ_j^k s$, or $s \sim_j^k q$.

3.2 Stability Analysis

Under the modified graph model for preference misperception, the hypergame equilibria can be obtained in two steps [15] as shown in Fig. 2. In Step 1, the individual games that are played by both of DM_i and DM_j are analyzed by using the standard stability analysis. As a result, individual stabilities and equilibria can be determined. A variety of solution concepts including Nash stability (Nash), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability (SEQ) has been defined within the GMCR framework [2],[7],[8]. In

Step 2, hypergame equilibria are ascertained. A state is a first level hypergame equilibrium for a given solution concept [2],[7],[8] if it is stable for DM_k in his or her own game in Step 1 for $k \in \{i, j\}$ under the particular solution concept.

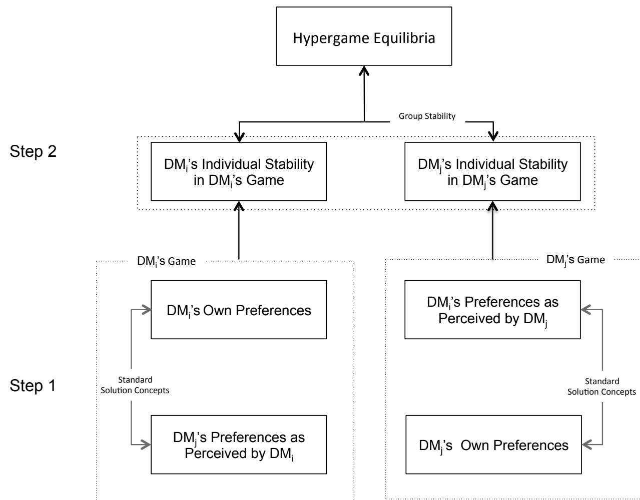


Fig. 2. First level hypergame equilibria

4 Case Study: The Cuban Missile Crisis

4.1 Background

In 1957, which was during the dictatorial reign of Batista, the United States of America (US) had control of most of the Cuban economy. As a result, many US companies had invested in the Cuban agriculture and tourism industries. However, in 1959, the Batista regime was overthrown by the educated middle class communist Fidel Castro. During his reign, most of the US investments in Cuba were nationalized and a strong relationship with the Soviet Union (USSR) was established. In October 1962, upon learning that the USSR had been installing missiles just over 90 miles off the American mainland, the US considered a number of different responses. The USSR was motivated to install missiles in Cuba for several reasons. One reason was to use it as a negotiation tool with the US to force it to dismantle its missiles in Turkey and Italy. Further information about the dispute can be found in [17],[18],[19],[1].

4.2 Modified Graph Model for the Cuban Missile Crisis

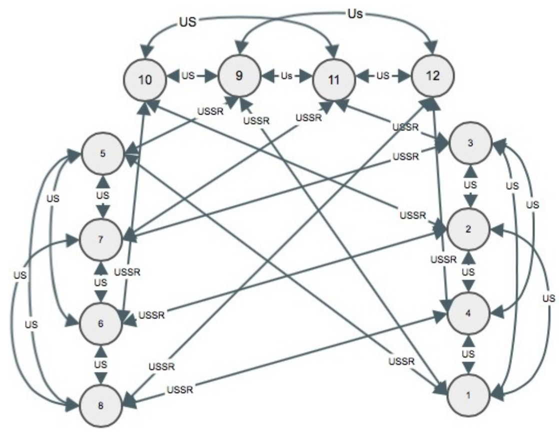
Two DMs are identified for the Cuban missile crisis: the US and the USSR. As of October 14, 1962, the US had two options: execute a surgical air strike or impose a blockade. The USSR also had two options: withdraw its missiles from Cuba or escalate the dispute.

In an option form, an option can be selected or not. Thus, the total number of possible states for the dispute can be mathematically calculated as $2^{Number of options}$. In this dispute, this comes to $2^4 = 16$. However, after removing the infeasible states, only 12 states remain. Table 1 lists the feasible states for the Cuban missile conflict. As can be seen in Table 1, each column that is composed of "Y" or "N" stands for a possible state or scenario that may happen in real life. Y indicates "yes", which means that the option opposite the Y is selected by the DM who controls it. N stands for "no", and means that the option is not taken.

Table 1. Feasible States in the Cuban Missile Crisis

	States											
Decision Makers	1	2	3	4	5	6	7	8	9	10	11	12
US												
1. Air Strike	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
2. Blockade	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
USSR												
3. Withdraw	N	N	N	N	Y	Y	Y	Y	N	N	N	N
4. Escalate	N	N	N	N	N	N	N	N	Y	Y	Y	Y

The preference relationships for the Cuban missile crisis are obtained based on the analysis provided by [17],[18],[19],[1]. The US preference relationship is based on the concern of avoiding the conflict evolving into nuclear war, and the desire for the USSR to withdraw its missiles. Therefore, the preference relationship for the US is found to be transitive and can be expressed by ordinal preferences (most to least preferred) as $\langle 5 \succ 7 \succ 6 \succ 8 \succ 3 \succ 2 \succ 4 \succ 1 \succ 12 \succ 10 \succ 11 \succ 9\rangle$. Moreover, the USSR also wishes to avoid nuclear war, and wishes also to avoid escalating the conflict if no surgical air strike is started first by the US. As a result, the preference relationship for the USSR is expressed also by ordinal preferences as $\langle 1 \succ 5 \succ 7 \succ 3 \succ 6 \succ 2 \succ 8 \succ 4 \succ 12 \succ 10 \succ 11 \succ 9\rangle$. One can use the preference relationships for both the US and the USSR to carry out the stability analysis under GMCR. However, the Cuban Missile Crisis encounters a very common form of hypergame, which is that one of the DMs misinterprets his or her opponent's preferences, yet none of the DMs are aware of any misinterpretation happening. As a result, the modified graph model for preference misperception must be used to conduct the stability analysis and calculate the hypergame equilibria. In particular, the USSR misinterprets the US preference relationship over the set of feasible states. As illustrated in [1],[17],[18],[19], the USSR did not expect a strong response from the US regarding installing the USSR missiles in Cuba. As a result, the preference relationship for the US is modified based on the USSR's perspective; that is $\langle 5 \succ 1 \succ 7 \succ 3 \succ 6 \succ 2 \succ 8 \succ 4 \succ 12 \succ 10 \succ 11 \succ 9\rangle$. Fig. 3 shows the integrated graph model for the Cuban Missile Crisis, which is composed of the graph model for movements as shown at the top and preference information as perceived by two DMs at the bottom.



	US Game
US's own preferences	5≻ 7 ≻ 6 ≻ 8 ≻ 3 ≻ 2 ≻ 4 ≻ 1 ≻ 12 ≻ 10 ≻ 11 ≻ 9
USSR's preferences as perceived by the US	1≻ 5 ≻ 7 ≻ 3 ≻ 6 ≻ 2 ≻ 8 ≻ 4 ≻ 12 ≻ 10 ≻ 11 ≻ 9

	USSR Game
US's preferences as perceived by the USSR	5≻ 1 ≻ 7 ≻ 3 ≻ 6 ≻ 2 ≻ 8 ≻ 4 ≻ 12 ≻ 10 ≻ 11 ≻ 9
USSR's own preferences	1≻ 5 ≻ 7 ≻ 3 ≻ 6 ≻ 2 ≻ 8 ≻ 4 ≻ 12 ≻ 10 ≻ 11 ≻ 9

Fig. 3. Modified graph model for the Cuban missile crisis

4.3 Stability Analysis and Equilibria

In this section, the stability analysis and compromise resolutions are identified based on the modified graph model for preference misperception. The two step explained in Section 3.2 can be used to ascertain the hypergame equilibria. The first step is to find the individual stability for both the US and the USSR. This can be accomplished by analyzing the dispute based on how each DM sees it and by using the standard soluation concepts. Table 2 shows the individual stability and the equilibria results for the US game. As can be seen, states 1, 2, 3, 6, and 8 are found to be weak equilibria for the dispute; that is, they are equilibria under both GMR and SMR solution concepts. In contrast, states 5 and 7 are found to be the strong equilibria for the dispute; that is, they are also equilibria under the SEQ solution concept. On the other hand, Table 3 shows the individual stability and the equilibria results for the USSR game. States 2, 3, 5, 6, 7, and 8 are found to be weak equilibria, and state 1 is found to be the strong equilibrium. That is, it is also equilibrium under Nash and SEQ solution concepts. After determining the individual stability analysis for both of the US and the USSR, one can easily calculate the hypergame equilibria, which is the second step. Table 4 shows the equilibria results for the first level hypergame. States 1, 2, 3, 5, 6, and 8 are found to be the weak equilibria, and state 7 is found to be the only strong equilibrium. State 7 is predicted to be a strong equilibrium under the US game in Table 2, but not under the USSR game in Table 3. That is, the USSR misperceives the US preferences; as a result, faces a surprise during the dispute.

Table 2. Stability Analysis for the US Game

		States											
	Solution Concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
US	Nash	NO	NO	YES	NO	YES	NO	NO	NO	\	\	\	YES
	SEQ	NO	NO	YES	NO	YES	NO	YES	NO	\	\	\	YES
	GMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
	SMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
USSR	Nash	YES	NO	NO	\	NO	YES	YES	YES	\	\	\	\
	SEQ	YES	NO	NO	\	YES	YES	YES	YES	\	\	\	\
	GMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
	SMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
Equilibrium	Nash	\	\	\	\	\	\	\	\	\	\	\	\
	SEQ	\	\	\	\	E	\	E	\	\	\	\	\
	GMR	E	E	E	\	E	E	E	E	\	\	\	\
	SMR	E	E	E	\	E	E	E	E	\	\	\	\

Table 3. Stability Analysis for the USSR Game

		States											
	Solution Concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
US	Nash	YES	NO	NO	NO	YES	NO	NO	NO	\	\	\	YES
	SEQ	YES	NO	NO	NO	YES	NO	NO	NO	\	\	\	YES
	GMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
	SMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
USSR	Nash	YES	NO	NO	\	NO	YES	YES	YES	\	\	\	\
	SEQ	YES	NO	NO	\	NO	YES	YES	YES	\	\	\	\
	GMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
	SMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
Equilibrium	Nash	E	\	\	\	\	\	\	\	\	\	\	\
	SEQ	E	\	\	\	\	\	\	\	\	\	\	\
	GMR	E	E	E	\	E	E	E	E	\	\	\	\
	SMR	E	E	E	\	E	E	E	E	\	\	\	\

Table 4. Stability Analysis for the First Level Hypergame

		States											
	Solution Concepts	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
US	Nash	NO	NO	YES	NO	YES	NO	NO	NO	\	\	\	YES
	SEQ	NO	NO	YES	NO	YES	NO	YES	NO	\	\	\	YES
	GMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
	SMR	YES	YES	YES	YES	YES	YES	YES	YES	\	\	\	YES
USSR	Nash	YES	NO	NO	\	NO	YES	YES	YES	\	\	\	\
	SEQ	YES	NO	NO	\	NO	YES	YES	YES	\	\	\	\
	GMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
	SMR	YES	YES	YES	\	YES	YES	YES	YES	\	\	\	\
Equilibrium	Nash	\	\	\	\	\	\	\	\	\	\	\	\
	SEQ	\	\	\	\	\	\	E	\	\	\	\	\
	GMR	E	E	E	\	E	E	E	E	\	\	\	\
	SMR	E	E	E	\	E	E	E	E	\	\	\	\

5 Conclusions and Future work

The modified graph model for preference misperception was defined and a two step procedure for identifying the first level hypergame equilibria was presented. The Cuban missile crisis was used to illustrate the foregoing development. Future work is needed to enhance the proposed model. More specifically, the model could be improved to handle different degrees of misperception among DMs. It is also worth investigating the possibility of modeling different forms of misperception, namely misperception about options and the DMs participating in the dispute within the structure of the GMCR.

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Graph Model for Conflict Resolution with Upper and Lower Probabilistic Preferences

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Abstract. We generalize the Graph Model for Conflict Resolution (GMCR), introducing the possibility of decision makers expressing their preferences among the possible conflict scenarios using upper and lower probabilities. After we introduce the model, we propose stability definitions (solution concepts) that are generalizations of the four standard stability notions commonly used in the GMCR model and relations between these definitions are stated. We deal with conflict situations that involve two decision makers. An application of the proposed model is presented and the analysis of this application highlights the advantages gained by allowing individuals to have the uncertainty about their own preferences expressed by upper and lower probabilities.

Key words: Graph Model for Conflict Resolution, Solution Concepts, Upper and Lower Probabilities, Probabilistic Preferences

1 Introduction

According to Kilgour and Hipel [1], a *strategic conflict* is an interaction among two or more decision makers (DMs) who make choices that together determine how the interaction evolves and each DM has preferences over the final state, or resolution. There are many different approaches in negotiation research for dealing with conflicts and they come from different fields such as operations research, computer science, psychology, political economy, systems engineering, social choice theory and game theory. These approaches address issues that span from how to design a reliable and efficient e-negotiation system [2] to the understanding of the role of emotions in negotiations [3]. The Graph Model for Conflict Resolution (GMCR) is a relevant technique, based on some important game theory concepts [4], to represent conflicts. It was presented by Kilgour et al. [5], and is an enhancement of the conflict analysis of Fraser and Hipel [6] and metagames analysis [7].

After defining the structure that represent the conflict, an important step is the stability analysis. In this step, the decision maker's preference has a fundamental role, since his possible moves from one state to another one is directly determined by his preferences over the states. However, it is not always the case that these preferences are clear or precise. Several generalizations of the GMCR try to capture other preference features that can better model real world situations. New preference structures are introduced, for example, in Li et al. [8] and Li et al. [9] (preference uncertainty for two-DM and multi-DM conflicts, respectively), Al-Mutairi et al. [10] (fuzzy preferences) and Hamouda, Kilgour and Hipel [11] (preference degree). Another formal approach to model preference uncertainty is to use probabilistic preferences. Campello [12] arguments that the use of such preferences can accommodate the fluctuations of behavior in the choices of individuals. Rêgo and Santos [13] introduced probabilistic preferences into GMCR, allowing for the possibility of decision makers expressing their preferences for state a over state b by the precise probability $P(a, b)$. Here, we called such a case *precise* probabilistic preferences. However, in some situations there may be not enough information to determine a precise probability that express the decision maker's preferences, i.e, the probabilistic preference can be imprecise.

We present here a generalization of the GMCR allowing the DMs to express their preferences using upper and lower probabilities [14]. The paper is organized as follows: in Section 2, we make a brief review of the literature about upper and lower probabilities; in Section 3, we propose the GMCR with imprecise probabilistic preferences for two DMs and we present new stability definitions for the proposed model; in Section 4, we present an application of the proposed model; and we conclude with final remarks on Section 5.

2 Review of literature

Situations in which individuals must make a decision have been modeled considering that they can be uncertain about the available scenarios and possible results of their actions. Here, the uncertainty is not about scenarios or actions' consequences, but the DM has uncertainty about his own preferences.

In the field of modeling beliefs, the most highly developed theory is the Bayesian theory. In this theory, beliefs are modeled by an unconditional probability $P(A)$ or by a conditional probability $P(A|B)$, which are precise numbers between zero and one. At first, the Bayesian theory can be applied in any problem involving uncertainty, but in practice it is difficult to satisfy all coherence conditions in order to determine precise probabilities [15]. In situations of real world, it is common that individuals express their preferences by linguistics assessments that can be vague.

Fine [14] sees the Bayesian theory as one that has an important role in modeling individuals beliefs, but questions the necessity of a precise measure of probability to represent real situations and arguments that *upper and lower probabilities* can be an alternative to model individual beliefs without a high level of precision. The theory of upper and lower probability is centered on a pair of functions $\underline{P}$ and $\overline{P}$, taking values in the unit interval, where $\underline{P}$ denotes the lower probability and $\overline{P}$ the upper probability. The approach is similar to standard probability measure, considering a sample space Ω and an algebra event $\mathcal{A}$ of Ω. $\mathcal{A}$ is the domain of the functions $\overline{P}$ and $\underline{P}$ and these must satisfy the following axioms:

1. $\underline{P}(A) + \overline{P}(A^c) = 1$;
2. $\underline{P}(\Omega) = 1$;
3. $\underline{P}(A) \geq 0$;
4. If A and B are disjoint events, then $\underline{P}(A \cup B) \geq \underline{P}(A) + \underline{P}(B)$ and $\overline{P}(A) + \overline{P}(B) \geq \overline{P}(A \cup B)$.

Probabilistic models of preferences have a long history. Luce [16] develops a probabilistic utility model in which $P(a, b)$ represents the probability that the DM *strictly* prefers the alternative a over b when presented to choose one of them. In such model, it is assumed that the choices of DMs have some kind of regularity that enable such preference to be modeled by a precise probability distribution. However, as in the case of modeling beliefs, it is not always possible identify precisely such probabilistic preference. Here, we propose to relax the assumption of precision and propose a new preference model based on upper and lower probabilities. Such upper and lower probabilistic preference functions have common domain $S \times S$ and must satisfy:

1. $\overline{P}(a, b) \geq \underline{P}(a, b) \geq 0$ for each $a, b \in S$,
2. $\underline{P}(a, b) + \overline{P}(b, a) \leq 1$ for each $a, b \in S$.

3 GMCR with imprecise probabilistic preferences

GMCR consists of a collection of graphs (S, A_i), one for each DM $i \in N = \{1, 2, 3, \ldots, n\}$, where all the graphs have the same set of vertices or nodes, $S = \{1, 2, \ldots, s\}$, representing the possible states of the conflict. The set of arcs A_i of the graph (S, A_i) represent the possible transitions that DM i can make from one state to another according to his available options. The set of states that DM i can achieve from a determined state s in a single step is denoted by $R_i(s)$, i.e., $R_i(s) = \{t \in S : (s, t) \in A_i\}$.

In the original GMCR, the preference is represented without uncertainty, as it is usual in models of game theory. In GMCR with precise probabilistic preferences introduced by Rêgo and Santos [13], it is allowed that the preference can be non-deterministic, i.e., a DM i can express his preference for a state a over a state b, using the probability $P_i(a, b)$, which indicates the chance of DM i choosing state a over state b, for every pair of states a and b in a conflict. Now, we consider that each DM i can express his uncertainty about his own preference between states a and b using lower and upper probabilities, $\underline{P}_i(a, b)$ and $\overline{P}_i(a, b)$, that satisfy the axioms presented in Section 2. Thus, if the current state of the conflict is a, a DM i imprecise probabilistic preference for state a over state b is represented now by the pair of lower and upper probabilities $\underline{P}(a, b)$ and $\overline{P}(a, b)$, respectively.

3.1 Stability Definitions for Conflicts with Two DMs

The stability analysis has a important role because it leads to determine solutions for the conflict. Here, we modify the following definitions: Nash stability [17, 18], general metarationality (GMR) [7], symmetric metarationality (SMR) [7] and sequential stability (SEQ) [6].

The stability definitions proposed here consider two profiles for the DMs: the *cautious* and the *risky*. The cautious DM is the one that acts always considering the lower probabilistic preference when analyzing his own choice and considers that the other DM acts always considering the upper probabilistic preference. As an example, suppose that a cautious DM knows that his lower and upper probabilistic preferences for chocolate ice cream over strawberry ice cream is, respectively, 0 and 0.6. As he knows that it is possible that his probabilistic preference is equal to zero, i.e. he knows that it is possible that he does not prefer chocolate over strawberry, for caution, he prefers to consider this lower probability. The cautious DM is averse to ambiguity. On the other hand, the risky DM is the one that acts always considering the upper probabilistic preferences when analyzing his own choice and considers that the other DM acts always considering the lower probabilistic preferences.

As in GMCR with precise probabilistic preferences, for the stability definitions, we consider parameters α, β and γ in the interval $[0,1]$. Now, we define two notions of improvement for a DM: a notion for the cautious DM and another for the risky DM. The set of improvements for a cautious DM is defined as $RL_i^{+\gamma}(s) = \{t \in R_i(s) : \underline{P}_i(t,s) > \gamma\}$, while the set of improvements for a risky DM is defined as $RU_i^{+\gamma}(s) = \{t \in R_i(s) : \overline{P}_i(t,s) > \gamma\}$. We also define the sets $\varphi L_i^{+\gamma}(s) = \{t \in S : \underline{P}_i(t,s) > \gamma\}$ and $\varphi U_i^{+\gamma}(s) = \{t \in S : \overline{P}_i(t,s) > \gamma\}$ of the states (not necessarily achievable from s) that are preferred over s by a cautious and a risky DM i, respectively. Note that $RL_i^{+\gamma}(s) \subseteq RU_i^{+\gamma}(s)$ and $\varphi L_i^{+\gamma}(s) \subseteq \varphi U_i^{+\gamma}(s)$, since if $s_1 \in RL_i^{+\gamma}(s)$ or $s_1 \in \varphi L_i^{+\gamma}(s)$, then $\underline{P}_i(s_1,s) > 1-\alpha$ and, therefore, it is true that $\overline{P}_i(s_1,s) > 1-\alpha$. Thus, $s_1 \in RU_i^{+\gamma}(s)$ or $s_1 \in \varphi U_i^{+\gamma}(s)$, respectively.

Table 1 shows what conditions a state s must satisfy in order to be cautious stable according to each stability definition. Thus, for example, a state s is cautious α-Nash stable for DM i if among all the states that i can achieve when he is in s there is no state such that he prefers to s with lower probability greater than $1-\alpha$. For example, a state s that is cautious 0.9-Nash stable for DM i is such that among all the states that i can achieve from s there is none that i prefers to s with lower probability greater than 0.10. The interpretations of the other cautious stability notions are similar. The risky stability definitions are easily obtained by replacing, in Table 1, $RL_i^{+(1-\alpha)}(s)$, $\varphi L_i^{+(1-\beta)}(s)$ and $RU_j^{+\gamma}(s_1)$ by $RU_i^{+(1-\alpha)}(s)$, $\varphi U_i^{+(1-\beta)}(s)$ and $RL_j^{+\gamma}(s_1)$, respectively.

3.2 Relations Among Stability Definitions and Other Results

Based on the standard stability definitions of the GMCR model [19], Rêgo and Santos [13] presented some relations among the precise probabilistic stability def-

Table 1. Conditions for state s be Cautious stable for DM i

Definition	Conditions
Cautious α-Nash Stability	$RL_i^{+(1-\alpha)}(s) = \emptyset$.
Cautious (α, β)-Metarationality	$\forall s_1 \in RL_i^{+(1-\alpha)}(s)$ $\exists s_2 \in R_j(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$.
Cautious (α, β)-Symmetric Metarationality	$\forall s_1 \in RL_i^{+(1-\alpha)}(s)$ $\exists s_2 \in R_j(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$ such that $R_i(s_2) \cap \varphi L_i^{+(1-\alpha)}(s) = \emptyset$.
Cautious (α, β, γ)-Sequential Stability	$\forall s_1 \in RL_i^{+(1-\alpha)}(s)$ $\exists s_2 \in RU_j^{+\gamma}(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$.

initions. Such relationships remain valid when considering the stability notions defined in the previous section. The proof is very similar the proof presented in [13], replacing $R_i^{+(1-\alpha)}(s)$, $\varphi_i^{+(1-\beta)}(s)$ and $R_j^{+\gamma}(s_1)$, in the *cautious* case, by $RL_i^{+(1-\alpha)}(s)$, $\varphi L_i^{+(1-\beta)}(s)$ and $RU_j^{+\gamma}(s_1)$, respectively, and in the *risky* case, by $RU_i^{+(1-\alpha)}(s)$, $\varphi U_i^{+(1-\beta)}(s)$ and $RL_j^{+\gamma}(s_1)$, respectively.

The next result shows that if a state is risky stable for a determined set of parameters considering some stability definition, then it is also cautious stable considering the same stability definition and the same set of parameters.

Theorem 3.1 *(a) If a state s is risky α-Nash stable for DM i, then s is cautious α-Nash stable for DM i.*

(b) If a state s is risky (α, β)-Metarational stable for DM i, then s is cautious (α, β)-Metarational stable for DM i.

(c) If a state s is risky (α, β)-Symmetric Metarational stable for DM i, then s is cautious (α, β)-Symmetric Metarational stable for DM i.

(d) If a state s is risky (α, β, γ)-Sequentially stable for DM i, then s is cautious (α, β, γ)-Sequentially stable for DM i.

Proof: For (a), suppose that s is risky α-Nash stable for DM i, then it follows that $RU_i^{+(1-\alpha)}(s) = \emptyset$. Since $RL_i^{+(1-\alpha)}(s) \subseteq RU_i^{+(1-\alpha)}(s)$, we have that $RL_i^{+(1-\alpha)}(s) = \emptyset$. Thus, s is cautious α-Nash stable for DM i.

For (b), suppose that s is risky (α, β)-Metarational stable for DM i. Then, $\forall s_1 \in RL_i^{+(1-\alpha)}(s) \subseteq RU_i^{+(1-\alpha)}(s)$, $\exists s_2 \in R_j(s_1) \cap (\varphi U_i^{+(1-\beta)}(s))^c \subseteq R_j(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$. Thus, s is cautious (α, β)-Metarational stable for DM i.

For (c), suppose that s is risky (α, β)-Symmetric Metarational stable for DM i. Then, $\forall s_1 \in RL_i^{+(1-\alpha)}(s) \subseteq RU_i^{+(1-\alpha)}(s)$, $\exists s_2 \in R_j(s_1) \cap (\varphi U_i^{+(1-\beta)}(s))^c \subseteq R_j(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$ such that $R_i(s_2) \cap \varphi L_i^{+(1-\alpha)}(s) \subseteq R_i(s_2) \cap \varphi U_i^{+(1-\alpha)}(s) = \emptyset$. Thus, s is cautious (α, β)-Symmetric Metarational stable for DM i.

For (d), suppose that s is risky (α, β, γ)-Sequentially stable for DM i. Then, $\forall s_1 \in RL_i^{+(1-\alpha)}(s) \subseteq RU_i^{+(1-\alpha)}(s)$, $\exists s_2 \in RL_j^{+\gamma}(s_1) \cap (\varphi U_i^{+(1-\beta)}(s))^c \subseteq RU_j^{+\gamma}(s_1) \cap (\varphi L_i^{+(1-\beta)}(s))^c$. Thus, s is cautious (α, β, γ)-Sequentially stable for DM i. ∎

4 Application

Rêgo and Santos [13] showed the importance of introducing probabilistic preferences in the GMCR by analyzing a modified version of an example presented in Hamouda [11]. Here, we modify this example allowing upper and lower probabilistic preferences for DMs.

Example 4.1 *The example considers an environmental conflict, in which there are two DMs: environmentalists (E) and developers(D). It is assumed that there are two types of DM D: one that gives low priority to environmentalist,* (D_U), *and the other,* (D_S), *who is more responsible in this sense than the first one. DM E can choose to be proactive P in promoting environmental responsibility or not, in which case they are called reactive R and the DM D can choose between being sustainable S or not, which is represented by U. Their preferences are originally given by:* $(P, S) \succ_E (R, S) \succ_E (P, U) \succ_E (R, U)$, $(R, U) \succ_{D_U} (P, U) \succ_{D_U} (R, S) \succ_{D_U} (P, S)$ *and* $(R, S) \succ_{D_S} (P, S) \succ_{D_S} (R, U) \succ_{D_S} (P, U)$.[1]

Now, we consider that there is uncertainty about the type of DM D and we assume that the chance of the type D being D_U *is represented by the lower and upper probabilities* $\underline{P}(D = D_U) = p_1$ *e* $\overline{P}(D = D_U) = p_2$. *From Axiom 1, presented in Section 2, we must have that* $\underline{P}(D = D_S) = 1 - p_2$ *and* $\overline{P}(D = D_S) = 1 - p_1$.

We consider here that if a DM prefers deterministically one state s_p *to another* s_q, *then both lower and upper probabilistic preference are equal to* 1, *i.e,* $\overline{P}_i(s_p, s_q) = \underline{P}_i(s_p, s_q) = 1$ *and, moreover,* $\overline{P}_i(s_q, s_p) = \underline{P}_i(s_q, s_p) = 0$. *According to this assumption, the upper and lower probabilistic preferences of DM E are equal to* $(1, 1)$ *for the cases in that E prefers deterministically a state over another and are equal to* $(0, 0)$, *in the opposite case.*

Consider now the DM D. In this case, we assume that if both types of DM D prefer state s_p *over state* s_q, *then* $\underline{P}_D(s_p, s_q) = \overline{P}_D(s_p, s_q) = 1$. *If both do not prefer state* s_p *over state* s_q, *then* $\underline{P}_D(s_p, s_q) = \overline{P}_D(s_p, s_q) = 0$. *While if only one type prefer state* s_p *over state* s_q, *then the upper and lower probabilistic preferences of DM D are given by the upper and lower probabilities of such type being chosen. Thus, the upper and lower probabilistic preferences of DM D are as shown in Table 2.*

Table 2. Imprecise Probabilistic preferences for DM D

D	(P, S)	(R, S)	(P, U)	(R, U)
(P, S)	(0, 0)	(0, 0)	$(1 - p_2, 1 - p_1)$	$(1 - p_2, 1 - p_1)$
(R, S)	(1, 1)	(0, 0)	$(1 - p_2, 1 - p_1)$	$(1 - p_2, 1 - p_1)$
(P, U)	(p_1, p_2)	(p_1, p_2)	(0, 0)	(0, 0)
(R, U)	(p_1, p_2)	(p_1, p_2)	(1, 1)	(0, 0)

[1] We use the notation $x \succ_i y$ for the case where DM i strictly prefers the object x to y. Moreover, the notation $x_1 \succ_i x_2 \succ_i \ldots x_{m-1} \succ_i x_m$ represents the preference order for DM i and it means that, for DM i, x_1 is strictly preferred to x_2, which in turn is strictly preferred to x_3 and so on.

Given this GMCR model, an stability analysis can be made to determine for which parameter values the states satisfy each one of the eight proposed stability definitions for each DM. If a state is stable for both DMs according to a particular stability notion, then it is said to be stable according to such stability notion. Table 3 shows for which parameter values state (R, S) satisfies each one of the proposed stability notions.The stability analysis for the other states can be done similarly.

Table 3. Imprecise Probabilistic Stability for state (R, S)

	For E	For D	Stable
Cautious α-Nash	$\alpha = 0$	$\alpha \leq 1 - p_1$	$\alpha = 0$
Risky α-Nash	$\alpha = 0$	$\alpha \leq 1 - p_2$	$\alpha = 0$
Cautious (α, β)-GMR	$\forall\alpha, \forall\beta$	$\alpha \leq 1 - p_1, \forall\beta$ or $\alpha > 1 - p_1, \beta \leq 1 - p_1$	$\alpha \leq 1 - p_1, \forall\beta$ or $\alpha > 1 - p_1, \beta \leq 1 - p_1$
Risky (α, β)-GMR	$\forall\alpha, \forall\beta$	$\alpha \leq 1 - p_2, \forall\beta$ or $\alpha > 1 - p_2, \beta \leq 1 - p_2$	$\alpha \leq 1 - p_2, \forall\beta$ or $\alpha > 1 - p_2, \beta \leq 1 - p_2$
Cautious (α, β)-SMR	$\forall\alpha, \forall\beta$	$\alpha \leq 1 - p_1, \forall\beta$	$\alpha \leq 1 - p_1, \forall\beta$
Risky (α, β)-SMR	$\forall\alpha, \forall\beta$	$\alpha \leq 1 - p_2, \forall\beta$	$\alpha \leq 1 - p_2, \forall\beta$
Cautious (α, β, γ)-SEQ	$\alpha = 0, \forall\beta, \forall\gamma$ or $\alpha > 0, \forall\beta, \gamma < p_2$	$\alpha \leq 1 - p_1, \forall\beta, \forall\gamma$ or $\alpha > 1 - p_1, \beta \leq 1 - p_1, \gamma < 1$	$\alpha = 0, \forall\beta, \forall\gamma$ or $0 < \alpha \leq 1 - p_1, \forall\beta, \gamma < p_2$ or $\alpha > 1 - p_1, \beta \leq 1 - p_1, \gamma < p_2$
Risky (α, β, γ)-SEQ	$\alpha = 0, \forall\beta, \forall\gamma$ or $\alpha > 0, \forall\beta, \gamma < p_1$	$\alpha \leq 1 - p_2, \forall\beta, \forall\gamma$ or $\alpha > 1 - p_2, \beta \leq 1 - p_2, \gamma < 1$	$\alpha = 0, \forall\beta, \forall\gamma$ or $0 < \alpha \leq 1 - p_2, \forall\beta, \gamma < p_1$ or $\alpha > 1 - p_2, \beta \leq 1 - p_2, \gamma < p_1$

5 Conclusion

In order to allow for imprecision in the modeling of probabilistic preferences, we extended the GMCR model allowing DMs to express their preferences using upper and lower probabilistic preferences. We then, modified the four standard stability notions commonly used in the GMCR proposing eight stability definitions that accommodate both cautious and risky behaviors of the DMs. We showed that the same relations of the stability notions of the GMCR with precise probabilistic preferences remain valid for the cautious and risky versions of the stability definitions proposed here. Moreover, we showed that every state that is stable according to a risky behavior is also stable according to the corresponding cautious behavior. Finally, in order to illustrate the usefulness of the proposed model, an application of the model was made to an hypothetical conflict.

The next step is to extend the definitions proposed here for conflicts with more than two DMs, allowing both non-cooperative and coalitional analysis.

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Grey-based Graph Model for Conflict Resolution with Multiple Decision Makers

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Summary. A definition of grey preference is designed for incorporation into the Graph Model for Conflict Resolution in order to model and represent uncertain human behaviour in a strategic conflict. In analyzing a strategic conflict, incomplete information regarding many conflict situations, cognitive limitations of decision makers, the interplay of stakeholders and the complexity of disputes make it hard to capture accurate preferences of all decision makers across all possible scenarios, or states. In this paper, a grey preference structure (based on grey numbers) is extended to represent decision makers' uncertain preferences in a graph model. Then grey stability definitions are provided and corresponding equilibria are defined for a grey-based conflict model with multiple decision makers.

Key words: graph model for conflict resolution, multiple decision makers, grey numbers, grey preferences, grey stability, grey equilibrium

1 Introduction

The Graph Model for Conflict Resolution (GMCR) constitutes a flexible systematic methodology for modelling and analyzing strategic conflicts [5]. Using four solution concepts—Nash Stability (R), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability(SEQ)—defined within a rigorous mathematical framework, stability analysis can be carried out for conflict models, so that insights can be accessed and reasonable suggestions be provided to stakeholders. To realize GMCR's role in real-world decision problems, a user-friendly decision support system named GMCR II was developed [6, 7]. To formally model a strategic conflict, the graph model contains four main fundamental components: (i) a set of DMs, (ii) a set of options for each DM, (iii) possible moves between feasible states controlled by each DM, and (iv) the relative preferences for each DM over the feasible states [5, 8].

In GMCR, if a DM has no incentive to move from the present state, the scenario is called stable for the DM. If a scenario is stable for all DMs in the conflict, it constitutes an equilibrium [9, 10, 11]. The relative preferences of each DM over potential scenarios in a conflict is a key factor in judging whether it is worthwhile for a DM to move from the initial state, thereby determining stable states, or equilibria according to the four solution concepts. Unfortunately, in real cases, it is sometimes hard for DMs to provide exact relative preferences over possible scenarios in a conflict because of limited information and the uncertainties of human judgement. To counter this problem, much valuable research has been carried out into how GMCR can take uncertain preferences of DMs into account. Some results are: a new preference relation structure considering "unknown" preferences of DMs [13], incorporation of information-gap model into GMCR [18], matrix representation of preference uncertainty [16], fuzzy preferences [1], and grey-based preferences [12]. These approaches extend the graph model for employment in conflict analysis when DMs hold uncertain preferences.

2 Grey Numbers and Grey Preference

Grey system theory, originally introduced by Julong Deng in 1982 [3], is a methodology that focuses on addressing systematic problems with uncertain information, which may be discrete or continuous numerical values[4, 14]. In grey system theory, a system with complete information is called a White System; a system with no information at all is referred to as a Black System; a system with partially known information is called a Grey System. The fundamental definitions of grey numbers and grey preferences are illustrated in this section.

2.1 Grey Numbers

In the study of a grey system, grey numbers are the most fundamental concept. In the original definitions, a white number is a real number, $x \in \mathbb{R}$. A grey number, written $\otimes x$, means an indeterminate real number that takes its possible values within an interval or a discrete set of numbers. Specifically, a discrete grey number $\otimes x$ is an unknown real number, taking its value from a finite set, denoted as $\otimes x \in \{x_1, x_2, \ldots, x_k\}$; while a continuous grey number $\otimes x$ is an interval, and is thought of as potentially taking a value within that interval, written $\otimes x \in [\underline{x}, \bar{x}]$, where $\underline{x}$, $\bar{x} \in \mathbb{R}$, and $\underline{x} \leqslant \bar{x}$, [14]. Yang and John[19] put forward a generalized definition of a general grey number, which allows grey numbers to represent uncertainty in a more general way.

Definition 1. A general grey number $\otimes x$ is an unknown real number with a clear lower bound $\underline{x}$ and an upper bound $\bar{x}$, $\underline{x}, \bar{x} \in \mathbb{R}$, taking its value from the closed interval, $[\underline{x}, \bar{x}]$, denoted [19]:

$$\otimes x \in \bigcup_{i}^{k} [\underline{x}_i, \bar{x}_i] \tag{1}$$

where $1 \leqslant k < \infty$. Note that $\underline{x}_i$, $\bar{x}_i \in \mathbb{R}$, and $\bar{x}_{i-1} < \underline{x}_i \leqslant \bar{x}_i < \underline{x}_{i+1}$. The lower bound $\underline{x} = \min\limits_i \underline{x}_i$ and the upper bound $\bar{x} = \max\limits_i \bar{x}_i$. This is a generalized definition of a grey number, because it can represent a discrete grey number, an interval grey number, a white number, and a union set of discrete grey numbers and continuous grey numbers.

- If $x_i = \underline{x}_i = \bar{x}_i$ for all $i = 1, 2, ..., k$, $\otimes x \in \{x_1, x_2, ..., x_k\}$ is a discrete grey number .
- If $k = 1$ and $\underline{x} = \underline{x}_i$ and $\bar{x} = \bar{x}_i$ for all $i = 1, 2, ..., k$, $\otimes x \in [\underline{x}, \bar{x}]$ is a continuous grey number .

– If $k = 1$ and $x = \underline{x}_i = \bar{x}_i$, the general grey number is a white number, $\otimes x = x$.

Let $\otimes x_1$ and $\otimes x_2$ be two general grey numbers, $\otimes x_1 \in \bigcup_i^m [\underline{x}_i, \bar{x}_i]$ and $\otimes x_2 \in \bigcup_j^n [\underline{x}_j, \bar{x}_j]$, $1 \leqslant m, n < \infty$. The arithmetic operations on general grey numbers are [19]:

$$\otimes x_1 + \otimes x_2 \in \bigcup_i^m \bigcup_j^n \left[\underline{x}_i + \underline{x}_j, \bar{x}_i + \bar{x}_j\right] \tag{2}$$

$$\otimes x_1 - \otimes x_2 \in \bigcup_i^m \bigcup_j^n \left[\underline{x}_i - \bar{x}_j, \bar{x}_i - \underline{x}_j\right] \tag{3}$$

$$\otimes x_1 \times \otimes x_2 \in \bigcup_i^m \bigcup_j^n [\min(\underline{x}_i\underline{x}_j, \underline{x}_i\bar{x}_j, \bar{x}_i\underline{x}_j, \bar{x}_i\bar{x}_j), \max(\underline{x}_i\underline{x}_j, \underline{x}_i\bar{x}_j, \bar{x}_i\underline{x}_j, \bar{x}_i\bar{x}_j)] \tag{4}$$

$$\otimes x_1 \div \otimes x_2 \in \bigcup_i^m \bigcup_j^n [\min\left(\frac{\underline{x}_i}{\underline{x}_j}, \frac{\underline{x}_i}{\bar{x}_j}, \frac{\bar{x}_i}{\underline{x}_j}, \frac{\bar{x}_i}{\bar{x}_j}\right), \max\left(\frac{\underline{x}_i}{\underline{x}_j}, \frac{\underline{x}_i}{\bar{x}_j}, \frac{\bar{x}_i}{\underline{x}_j}, \frac{\bar{x}_i}{\bar{x}_j}\right)] \tag{5}$$

Note that in (5), for all $j = 1, \ldots, n$, either $\bar{x}_j < 0$ or $\underline{x}_j > 0$; otherwise, the operation is undefined.

2.2 Grey Preference Degree

A grey preference uses generalized grey numbers, ranging from 0 to 1, to indicate a DM's preference degree for one state over another.

Definition 2. Let $D[0,1]^{\otimes}$ represent the set of all grey numbers within the interval $[0,1]$. A *grey preference* is represented by a matrix $\otimes P = (\otimes p_{ij})_{m \times m}$, where

$$\otimes p(s_i, s_j) = \otimes p_{ij} \in D[0,1]^{\otimes} \tag{6}$$

represents the *grey preference degree (GPD) for state s_i over s_j*. The grey preferences satisfy $\underline{p}_{ij}{}^l + \bar{p}_{ji}{}^l = \underline{p}_{ji}{}^l + \bar{p}_{ij}{}^l = 1$ for all $i, j = 1, 2, \ldots, m$, and $\otimes p_{ii} = 0.5$, for all $i = 1, 2, \ldots, m.$, when $\otimes p_{ij} = \bigcup_l^L \left[\underline{p}_{ij}{}^l, \bar{p}_{ij}{}^l\right]$ and $\otimes p_{ji} = \bigcup_l^L \left[\underline{p}_{ji}{}^l, \bar{p}_{ji}{}^l\right]$, where $1 \leqslant l < \infty$.

2.3 Grey Relative Certainty of Preference

The grey relative certainty of preference is defined to represent the intensity of preference of one state over another. As mentioned above, $\otimes p(s_i, s_j)$ denotes the grey preference degree for state s_i over s_j, while $\otimes p(s_j, s_i)$ can represent the grey preference degree for state s_j over s_i, then the following definition represents the grey relative certainty of preference for s_i over s_j.

Definition 3. Let $\otimes p^k(s_i,s_j)$ represent the grey preference degree for state s_i over s_j of DM $k \in N$, and $D[-1,1]^{\otimes}$ represent the set of all grey numbers within the interval $[-1,1]$. The *grey relative certainty of preference (GRCP) for DM k of state s_i relative to s_j* is

$$\otimes r^k(s_i,s_j) = \otimes p^k(s_i,s_j) - \otimes p^k(s_j,s_i) \tag{7}$$

In (7), $\otimes r^k(s_i,s_j) \in D[-1,1]^{\otimes}$. To simplify the notation, $\otimes r^k(s_i,s_j)$ is written as $\otimes r^k_{ij}$ in the following parts of this paper. Then, a grey relative certainty of preference for DM k in a conflict can be represented by a matrix $(\otimes r^k_{ij})_{m\times m}$.

$$\otimes r^k = \begin{bmatrix} \otimes r^k_{11} & \otimes r^k_{12} & \dots & \otimes r^k_{1m} \\ \otimes r^k_{21} & \otimes r^k_{22} & \dots & \otimes r^k_{2m} \\ \dots & \dots & \dots & \dots \\ \otimes r^k_{m1} & \otimes r^k_{m2} & \dots & \otimes r^k_{mm} \end{bmatrix} \tag{8}$$

3 Grey-based Graph Model for Conflict Resolution with Multiple Decision Makers

In this paper, when multiple DMs are involved in a conflict, the grey preference structure is employed to represent uncertain preferences of these DMs, and identify states that are worthwhile for one or more DMs to move to. Note that the unilateral moves from the initial state for DMs in the grey-based graph model is the same as the definition of ulnilateral moves in GMCR. Considering uncertain preferences of DMs, the grey unilateral improvements (GUIs) from a given state depend on two more factors: anticipated preference (AP) and grey satisficing threshold (GST).

3.1 Anticipated Preferences of Decision Makers

In real world conflicts, DMs having different characteristics (optimism, pessimism and neutrality) may choose different strategies within the same decision context [15, 17, 2]. Thus, estimating possible reactions of DMs with uncertain preferences requires taking characteristics of DMs into account. Note that GRCP is expressed in the form of a general grey number. Then, AP is provided based on three forms of characteristics of DMs: optimistic, pessimistic and neutral to estimate the preference of a DM expressed by GRCP.

Definition 4. *For $k \in N$, $s_i, s_j \in S$, let $\otimes r^k(s_i,s_j) = \bigcup_l^n [\underline{x}_l, \bar{x}_l]$ denote the GRCP for DM k of s_i relative to s_j, and let ${\underline{r}_{ij}}^k$ and ${\bar{r}_{ij}}^k$ represent the lower bound and the upper bound of $\otimes r^k(s_i,s_j) = \bigcup_l^n [\underline{x}_l, \bar{x}_l]$ respectively. Then, the DM k's anticipated preference for s_i over s_j, $AP^k(s_i,s_j)$, is:*

– *If DM k is pessimistic, then*

$$AP^k(s_i,s_j) = {\underline{r}_{ij}}^k \tag{9}$$

– *If DM k is optimistic, then*

$$AP^k(s_i, s_j) = \bar{r}_{ij}{}^k \tag{10}$$

– *If DM k is neutral, then*

$$AP^k(s_i, s_j) = \begin{cases} \frac{1}{n}\sum\limits_{l=1}^{n} \underline{x}_l, & \textit{if } \underline{x}_l = \bar{x}_l \textit{ for all } l = 1, 2, \ldots, n \\ \frac{\sum\limits_{l=1}^{n}(\bar{x}_l - \underline{x}_l)(\frac{\bar{x}_l + \underline{x}_l}{2})}{\sum\limits_{i=1}^{n}(\bar{x}_l - \underline{x}_l)}, & \textit{otherwise} \end{cases} \tag{11}$$

Definition 5. For $k \in N$ and $s, s_i \in S$, let $AP^k(s_i, s)$ denote the AP of DM k for state s_i over s. DM k would prefer to move from state s to s_i, if and only if $AP^k(s_i, s) \geqslant \gamma_k$, where γ_k is called the *grey satisficing threshold of DM k*.

The GST of a DM means the degree of confidence over which a state is worthwhile for a DM to move to, otherwise the DM prefers to stay. Specifically, a move is worthwhile only when the AP is greater or equal to the GST for the DM, based on his characteristics. In a conflict, DMs may have different GSTs.

3.2 Grey Unilateral Improvement

Since AP and GST have been standardized and explained, a DM's grey unilateral improvement is introduced as follows:

Definition 6. For $k \in N$ and $s \in S$, let γ_k be the GST for DM k. Recall that $R_k(s)$ denotes the set of states reachable from the state s of DM k. A state $s_i \in R_k(s)$ is called a *grey unilateral improvement (GUI) from s for DM k*, if and only if $AP^k(s_i, s) \geqslant \gamma_k$.

A GUI is a reachable state by a DM from the initial state, and the state is worthwhile for the DM to move to. Specifically, a GUI s_i is a state within the reachable list for DM k from state s, and DM k's AP for s_i over s is greater than or equal to his/her GST.

Definition 7. For $s \in S$ and $k \in N$, let $R_k(s)$ denote the set of states reachable from the state s of DM k, and γ_k be the GST for DM k. The *grey unilateral improvement list , denoted* $\otimes R^+_{k,\gamma_k}(s)$, is the collection of all GUIs from s for DM k, represented mathematically as

$$\otimes R^+_{k,\gamma_k}(s) = \{s_i \in R_k(s) : AP^k(s_i, s) \geqslant \gamma_k\} \tag{12}$$

When more than two DMs are involved in a conflict, joint unilateral improvements for two or more DMs must be taken into account. The unilateral improvement list for n $(n > 1)$ DMs from a given state represents the collection of all possible states to which some or all of the DMs can move via a legal sequence of movements, and each movement is a grey unilateral improvement. A legal sequence of moves means that the same DM may move more than once, but not twice consecutively.

Definition 8. For $s \in S$, $H \subseteq N$ and $H \geq 2$, let $H = \{1, 2, \ldots, h\}$, and $\gamma_H = \{\gamma_1, \gamma_2, \ldots, \gamma_h\}$ represent the set of GUIs for corresponding DMs in H. Let $\Omega_H^+(s, s_i)$ denote the set of all last DMs in legal sequences allowable for unilateral improvement from s to s_i. Then, *the grey unilateral improvement(s) list for two or more DMs* $\otimes R_{H,\gamma_H}^+(s)$ *from state s for* H is defined inductively as

(1) if $k \in H$, and $s_1 \in \otimes R_{k,\gamma_k}^+(s)$, then $s_1 \in \otimes R_{H,\gamma_H}^+(s)$ and $k \in \Omega_H^+(s, s_1)$

(2) if $s_1 \in \otimes R_{H,\gamma_H}^+(s)$, $k \in H$, $s_2 \in \otimes R_{k,\gamma_k}^+(s_1)$, and $\Omega_H^+(s, s_1) \neq \{k\}$, then $s_2 \in \otimes R_{H,\gamma_H}^+(s)$ and $k \in \Omega_H^+(s, s_2)$

Note that the definition stops only when no new state can be added. A joint grey unilateral improvement from a given state by multiple DMs is a state that is in the reachable list for these DMs from the initial state and worthwhile for some or all of the DMs. Specifically, if a group of DMs, H, moves the conflict from state s_1 to s_2 via a legal sequence of moves and each movement is a grey unilateral improvement for corresponding DM judged by the Definition 6, then s_2 is a grey unilateral improvement for H, as well as are other movements. The grey unilateral improvement list for multiple DMs is the collection of all grey unilateral improvements from the given state for any non-empty subset of the DMs.

3.3 Grey Stability Definitions and Equilibria

The four basic grey-based stabilities in a strategic conflict are defined for a graph model having any finite number of DMs greater than unity. Specifically, grey Nash stability (GR), grey general metarationality (GGMR), grey symmetric metarationality (GSMR), and grey sequential stability (GSEQ) are introduced. These definitions depend on unilateral moves controlled by DMs, GUIs, GSTs, characteristics of DMs and their corresponding APs. Note that $S = \{s_1, s_2, \ldots, s_m\}$, $m > 1$ denotes the set of feasible states and N represents the set of DMs. The formal definitions of the four grey stabilities are given below.

Definition 9. A state $s \in S$ is *grey Nash stable or grey rational* for DM k, given by $s \in S_k^{GR}$, if and only if $\otimes R_{k,\gamma_k}^+(s) = \emptyset$.

If there is no state that is reachable from the initial state and is worthwhile for a DM to move to based on his characteristics and satisficing criterion, then the state is GR for the DM. In particular, a state $s \in S$ is GR stable for DM k if and only if the DM has no GUI from s.

Definition 10. A state $s \in S$ is *grey general metarational* for DM k, denoted by $s \in S_k^{GGMR}$, if and only if for every $s_1 \in \otimes R_{k,\gamma_k}^+(s)$ there exists at least one $s_2 \in R_{N-\{k\}}(s_1)$ such that $AP^k(s_2, s) < \gamma_k$.

If DM k chooses to move from s to a GUI, s_1, and the other DMs, $N - \{k\}$, have at least one unilateral movement from state s_1 to a state s_2 , which is less preferred for DM k than s, based on his preference, characteristics, and satisficing criterion, then the GUI from s to s_1 for DM k is blocked. If every GUI from s by DM k can be blocked by some or all the other DMs' unilateral movements, then the state s is GGMR for DM k.

Definition 11. A state $s \in S$ is *grey sequential stable* for DM k, denoted by $s \in S_k^{GSEQ}$, if and only if for every $s_1 \in \otimes R_{k,\gamma_k}^+(s)$ there exists at least one $s_2 \in \otimes R_{N-\{k\},\gamma_{N-\{k\}}}^+(s_1)$ such that $AP^k(s_2, s) < \gamma_k$.

If DM k chooses a GUI s_1 from state s to move to, and the other DMs, $N - \{k\}$, have at least one GUI from state s_1 to s_2, which is not worthwhile for DM k to move from s based on his preference, characteristics, and satisficing criterion, then the GUI from s to s_1 by DM k is blocked by other DMs' credible action. If every GUI from s by DM k can be blocked by some or all the other DMs using GUIs given in Definition 8, then the state s is GSEQ for DM k.

Definition 12. *A state $s \in S$ is* grey symmetric metarational *for DM k, denoted by $s \in S_k^{GSMR}$, if and only if for every $s_1 \in \otimes R_{k,\gamma_k}^+(s)$ there exists at least one $s_2 \in R_{N-\{k\}}(s_1)$ such that $AP^k(s_2, s) < \gamma_k$, and $AP^k(s_3, s) < \gamma_k$ for all $s_3 \in R_k(s_2)$.*

If DM k chooses to move to a GUI s_1 from s, and the other DMs, $N - \{k\}$, have subsequent unilateral movements from state s_1 to s_2, which is not worthwhile for DM k from s to move to, and neither is any unilateral movement of DM k from s_2, based on his preference, characteristics, and satisficing criterion, then the GUI from s to s_1 is blocked for DM k. If every GUI from s by DM k can be blocked in the manner described above,, then the state s is GSMR for DM k.

Definition 13. A state $s \in S$ is called a *grey equilibrium* under a specific grey stability definition if and only if s is grey stable for all DMs under that grey stability definition.

This research, using grey numbers to express uncertain preferences of DMs, aims to define grey-based stability concepts and corresponding equilibria within the GMCR structure, thereby extending the graph model methodology. These definitions can account for more missing preference information of a multiple participant-multiple objective decision model, and therefore, provide more realistic resolutions for a conflict being studied in the face of uncertainty.

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The Inverse Approach to Conflict Resolution in Environmental Management

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Abstract. The recently developed Inverse approach to the Graph Model for Conflict Resolution (Inverse GMCR) is used to model an environmental conflict that occurred in Elmira, a small agricultural town in southwestern Ontario, Canada [5]. The outcome of the conflict is examined using coalition analysis and from a negotiation perspective. These approaches are compared to emphasize the contribution of Inverse GMCR.

Key words: conflict resolution, graph model, Inverse GMCR, negotiation

1 Introduction

Negotiation and mediation are vital components of conflict resolution. GMCR is an established methodology to model and analyze conflicts. However, it does not have the capacity to explicitly model negotiation and third party intervention. Therefore, the authors developed a new Inverse GMCR to model negotiation and third party intervention [12] [13] [11].

2 The Graph Model for Conflict Resolution

GMCR is a methodology for strategic conflict modeling and analysis. It is robust, easy-to-use, flexible, and insightful in results interpretation [1, 2, 7, 10].

GMCR was developed in the early 1980s and is being continually enhanced [9]. The essence of GMCR is its ability to strategically analyze moves and counter moves within a conflict to predict equilibria based on a number of stability definitions.

Basic stability definitions include Nash stability [14], sequential stability (SEQ) [3] [4], general metarationality (GMR), and symmetric metarationality (SMR) [6]. These stability definitions determine how stable a state is for each decision maker (DM) and whether a DM is motivated to move from it. The final result of GMCR is determining the equilibrium of each state by examining its stability across all DMs.

2.1 Procedure

In a real world conflict, modeling builds the foundation for GMCR. This is done through identifying the five components of a conflict: DMs, options for every DM, feasible states, allowable transitions, and relative preferences. After the modeling stage, the likely final resolution is determined through analyzing the conflict from every DMs viewpoint by: determining individual stability for every DM, overall equilibria, and sensitivity analysis.

The flow chart in Figure 1 outlines the two stages of the standard GMCR procedure (adapted from [1]).

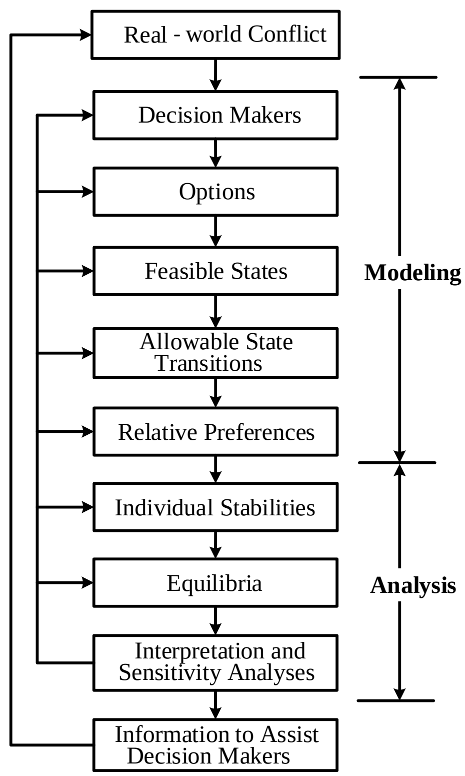

Fig. 1. The basic procedure of applying the GMCR methodology to a real world conflict (adapted from [1])

3 The Inverse GMCR

Although GMCR provides an excellent outline to structure and examine conflicts, it proves challenging in understanding the comparative inclinations of the DMs involved in the dispute. Negotiators need the ability to motivate DMs to move to a more desired resolution. To allow this to happen, a negotiation tool containing information about DMs' motivations is required.

Introduction of Inverse GMCR allows the negotiator to predict all likely inclinations to achieve the desired resolution to the conflict. This tool is useful not only to negotiators, but can be used by actual stakeholders to influence their adversaries.

The standard GMCR procedure and the Inverse GMCR each follow an order of steps as illustrated in Figure 1 for the standard GMCR procedure, and Figure 2 for Inverse GMCR. The similarities in the order of steps are in the determination of (1) the DMs and (2) the option choices for each DM. While in the standard GMCR procedure the next step is to determine the rankings of states for each DM, Inverse GMCR will instead determine the desired outcome and stability definition. What results in Inverse GMCR is a record of likely state rankings that will make the desired resolution stable under the chosen stability definition. In other words, Inverse GMCR is a modification of the standard GMCR to function as a negotiation tool rather than a prediction tool.

4 Application

4.1 The Elmira Conflict

In late 1989, a controversy surfaced in the small town of Elmira, located north of the cities of Kitchener and Waterloo in southwestern Ontario, Canada. With a population of about 12,000 residents, Elmira is known for its agriculture and various industries, including a pesticide and rubber manufacturer, Uniroyal Chemical Ltd (UR). The municipal water supply of the town was formerly obtained from an underground aquifer, until the Ontario Ministry of Environment (MoE) uncovered that this fresh water supply was polluted with a carcinogen chemical, N-nitroso dimethylamine or NDMA.

Local residents, the Regional Municipality of Waterloo, and the Township of Woolwich (LG) collectively suspected UR to have caused the pollution, citing a long history of environmental problems and NDMA being a by-product of their manufacturing. Subsequently, the MoE issued a Control Order (CO) under the *Environment Protection Act of Ontario*, which required UR to, among other things, execute the necessary cleanup under the supervision of the MoE. Soon after, as per the *Environment Protection Act*, UR exercised its right to appeal the CO which allowed a hearing to decide whether the CO should be enforced, a modified version be proposed, or whether it should be dismissed.

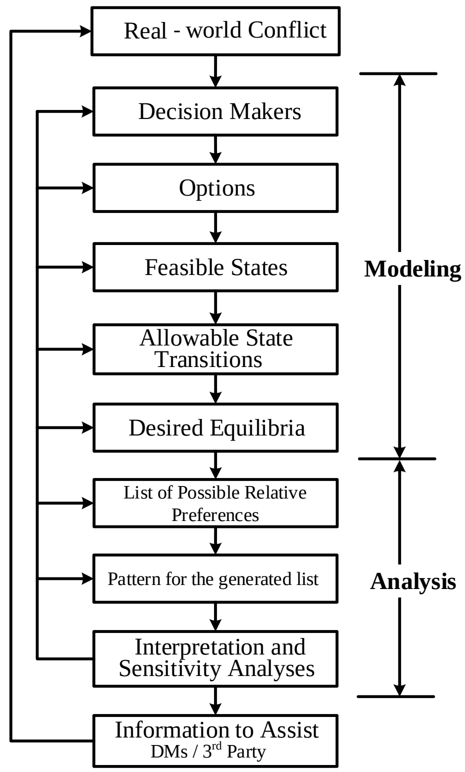

Fig. 2. Inverse GMCR procedure in a real world conflict (modified from [1])

In August 1991, the first conflict study over the Elmira dispute was conducted by K.W. Hipel, D.M. Kilgour, and L. Fang as the Domain Experts [8].The goal of the conflict modeling and analysis was to assess how a negotiated resolution could be reached between the MoE with its goal to execute the CO, UR with its objective to modify or dissolve the CO, and the LG that aimed to protect the health of its citizens as well as to save its financial base.

The graph model for this conflict was established by Hipel et al. [5] containing three DMs: MoE, UR, and LG. MoE can control a single option of modifying the CO, making it more acceptable to UR (Modify). UR has three options: to delay the appeal process (Delay), to accept the CO whether modified or not (Accept), or to abandon the Elmira operations (Abandon). LG has one option of insisting the original CO be applied (Insist). Table 1 outlines the DMs, their options, and the 12 feasible states for the conflict. In the table, 'Y' denotes 'Yes' meaning that option in the corresponding row is taken while 'N' denotes 'No' indicating that the option is not taken. States 5,6,11, and 12 are shaded indicating that UR abandons its operations in Elmira and thus ending the conflict.

Table 1. DMs, Options, and States for the Elmira Conflict

DM	State #	1	2	3	4	5	6	7	8	9	10	11	12
MoE	Modify	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
UR	Delay	Y	Y	N	N	N	N	Y	Y	N	N	N	N
	Accept	N	N	Y	Y	N	N	N	N	Y	Y	N	N
	Abandon	N	N	N	N	Y	Y	N	N	N	N	Y	Y
LG	Insist	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y

According to the aforementioned background, the analysts derived the preference rankings represented in Table 2 [5]. The preferences are ordered from the most preferred states on the left to the least preferred states on the right. Equally preferred states are shaded. Consequently, the standard GMCR produced the equilibria results outlined in Table 3.

Table 2. Preferences from Most to Least Preferred States for the Elmira Conflict

DM	Most Preferred											Least Preferred
MoE	9	3	4	10	7	1	2	8	5	6	11	12
UR	1	4	10	7	5	6	11	12	2	3	9	8
LG	9	3	7	1	10	8	4	2	5	6	11	12

Table 3. Equilibria Results for the Elmira Conflict

State #	1	2	3	4	5	6	7	8	9	10	11	12
Nash					✓	✓	✓			✓	✓	✓
SEQ					✓	✓	✓			✓	✓	✓
GMR	✓			✓	✓	✓	✓			✓	✓	✓
SMR	✓			✓	✓	✓	✓			✓	✓	✓

Table 4 illustrates the evolution of the Elmira conflict. The original analysis suggested that the conflict would be deadlocked in equilibrium state 7. However, on October 7, 1991, MoE and UR announced an agreement to modify the CO making state 10 the final equilibrium [8]. The authors then investigated a new area of coalition analysis within GMCR to explain the equilibrium jump from state 7 to state 10 as there are no possible unilateral moves by either MoE or UR from state 7 to state 10. In the next section, a new insight and explanation is provided using Inverse GMCR approach.

Table 4. The Evolution of the Elmira Conflict

DM	State #	1		7		10
MoE	Modify	N		N	→	Y
	Delay	Y		Y	→	N
UR	Accept	N		N	→	Y
	Abandon	N		N		N
LG	Insist	N	→	Y		Y

4.2 The Inverse GMCR Analysis

The main use of Inverse GMCR is to choose a more desirable state and understand how it can be achieved. An alternative use of Inverse GMCR is to understand how a certain state can be avoided or, in other words, can be made unstable. Looking back at the Elmira conflict, MoE is clearly better off having UR accept a modified CO rather than abandon its operations. Being in state 7, in which UR continues to delay, is not beneficial to the town of Elmira nor to MoE. The original preference ranking suggested that MoE prefers state 7 more than state 8 in which MoE has to modify the CO. If a negotiator wants state 7 (the original equilibrium) to be unstable, then state 8 has to be more preferred than state 7 by MoE allowing UR to make a unilateral improvement to state 10. This information is obtained using Inverse GMCR procedure by determining the rules that make state 7 unstable while maintaining the final equilibrium. Table 5 illustrates the evolution of the conflict as explained using Inverse GMCR. In essence, Inverse GMCR provides the analyst with various scenarios to reach the desired resolution while reducing the probability of less desirable states.

Table 5. The Evolution of the Elmira Conflict Using Invese GMCR

DM	State #	1		7		8		10
MoE	Modify	N		N	→	Y		Y
	Delay	Y		Y		Y	→	N
UR	Accept	N		N		N	→	Y
	Abandon	N		N		N		N
LG	Insist	N	→	Y		Y		Y

The coalition analysis provides an explanation of an equilibrium jump in which both MoE and UR have to cooperate to move together to a mutually preferred state. Using Inverse GMCR, an explanation is provided to allow unilateral improvements for these two DMs without having to cooperate.

5 Conclusions

Understanding the dynamics is a vital element in conflict modeling and analysis. Inverse GMCR is a valuable negotiation tool that explains how a state can or cannot be achieved. It allows the negotiator to motivate DMs to move toward a desired equilibrium state. The Elmira dispute is a suitable environmental conflict that illustrates the advantage of using a variety of conflict modeling approaches, standard GMCR, coalition analysis, and Inverse GMCR, to achieve a sustainable equilibrium. Applying these approaches provides deeper insights and comprehensive understanding about the conflict at hand.

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Application of the Graph Model for Conflict Resolution to the Jackpine Mine Expansion Dispute in the Alberta Oil Sands

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Abstract. The conflict of Jackpine Mine Expansion project is systematically studied using the Graph Model for Conflict Resolution methodology to gain insights. The results imply that the Federal Government of Canada is more concerned about the economic benefits generated by the oil sands projects. It is suggested that more efforts should be put on the environment conservation by the government.

Keywords: Graph Model for Conflict Resolution, Jackpine Mine Expansion, Oil Sands

1 Introduction

The oil sands are one of the most controversial energy resources in Canada. They create great economic benefits but at the same time could cause significant environmental damages. Environmental issues result in protest over the oil sands development at the Jackpine Mine Expansion project. The dispute commenced when Shell intended not to fulfill its commitments with regard to the significant reduction of the greenhouse gas emission.

To formally study the conflict of the Jackpine Mine Expansion dispute, the Graph Model for Conflict Resolution (GMCR) methodology is utilized. The dispute is divided into three phases because each phase involves different decision makers and corresponding options. Phase I commenced in 2007 when Shell was unwilling to implement its commitments of reducing greenhouse gas emissions, and ended when a joint federal and provincial review panel was established in September 2011. Phase II ran from September 2011 until the joint review panel released a report in July 2013. Phase III started from July 2013 and concluded when the Federal Government of Canada issued a decision statement in December 2013.

2 Background of the Jackpine Mine Expansion Dispute

The Jackpine Mine Expansion project is an oil sands mining program located about 70 km north of Fort McMurray on the east side of the Athabasca River, and it extends to the north of the current Jackpine Mine project. A location map of the project can be seen in Fig. 1.

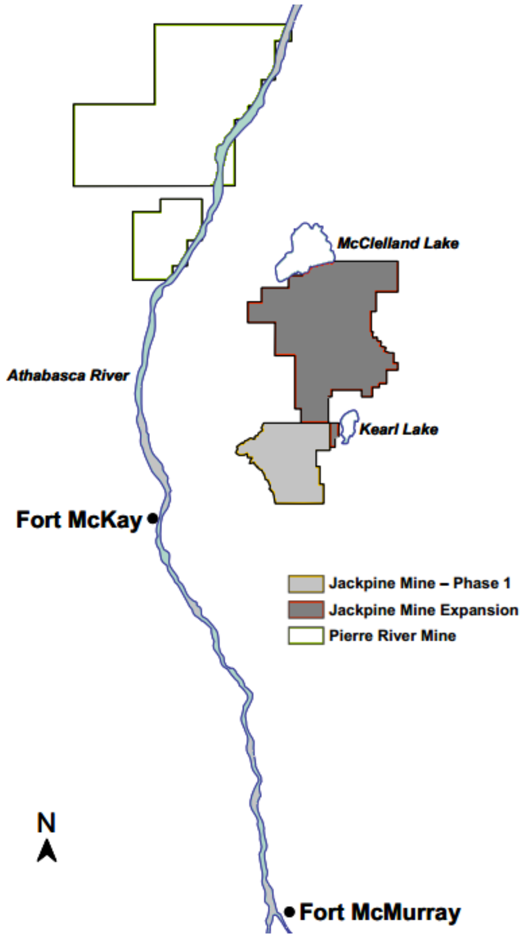

Fig. 1. Map of the Project Location [1]

On May 31, 2002, Shell submitted an application for the Jackpine Mine-Phase I (JMPI). The JMPI project received regulatory approval by the governments of Alberta and Canada in 2004, and began operations in August 2011 [1]. On September 18, 2003, Shell and Oil Sands Environmental Coalition (OSEC) reached a bilateral agreement which included commitments to significantly reduce greenhouse gas pollution from the JMPI project. OSEC believed that the approval of the JMPI project was assisted by this agreement [2]. In December 2007, Shell submitted an application for the Jackpine Mine Expansion (JPME) project which would increase the production by 100,000 barrels of bitumen per day. The JMPE project was approved in January 2009.

During the period from November 2007 to January 2009, in written correspondence and face-to-face meetings, OSEC realized that Shell did not intend to fulfill the commitments, rather it planned to comply with future federal greenhouse gas (GHG) regulatory requirements [2]. OSEC believed that even if Shell were to comply with the federal GHG reduction requirements, Shell's GHG pollution from these projects would increase by an estimated 900,000 tonnes without the commitments. OSEC was disappointed and decided to take action. On behalf of the OSEC, the Pembina Institute submitted a complaint to the Alberta Energy Resources Conservation Board (ERCB) and the Canadian Environmental Assessment Agency (CEAA) on April 7, 2009. In the complaint, OSEC requested a new public hearing regarding the approval of JPME project because Shell reneged on written agreements with OSEC [3].

On September 20, 2011, a joint federal and provincial review panel was established, and a public hearing was conducted on October 29, 2012 in Fort McMurray, Alberta. Shell and OSEC both provided supplemental information to the panel. On July 9, 2013, the Joint Review Panel (JRP) released a report claiming that there would be significant adverse project effects on certain wildlife and vegetation, but these effects could be justified. The project was recommended to be approved with a series of recommendations [4].

The Panel's report was taken into account when the federal government made a final decision. On December 6, 2013, the Federal Ministry of the Environment issued a decision statement declaring that the project might proceed in accordance with conditions set out in the statement [5]. The Pembina Institute reacted to the decision on December 9, 2013, stating that it was disappointed about the decision [6]. A lawsuit was filed to the Federal Court by the Athabasca Chipewyan First Nation in January 2014.

3 Modeling and Analysis

GMCR is a comprehensive and flexible methodology for modeling and analyzing strategic conflict [7]. This technique requires relatively less information to construct a model: decision makers (DMs), options and preferences. For the JPME Phase I conflict, the DMs are Shell, OSEC, and ERCB. The options for Shell are to "comply with the federal GHG requirements" and "negotiate with OSEC to reach a new agreement". OSEC's options include to "request a public hearing" and "negotiate with Shell". The option for ERCB is to "hold a public hearing". The DMs and their options for the three phases of the JPME conflict are summarized in Table 1. A dash "—" in the table means the corresponding DM is not involved in that phase.

A conflict with n options has 2^n states in total. However, not all states are possible to occur in reality, the infeasible states should be eliminated. For example, in Phase I, Shell will not choose its two options simultaneously, and must choose at least one of its options. OSEC is the same. Moreover, ERCB will conduct a public hearing if and only if OSEC requests one. The elimination process leaves six feasible states in Phase I of the conflict, as shown in Table 2. In this table, letter "Y" means the option is selected while "N" means the option is not chosen.

Table 1. Summary of Decision Makers and Options in the JPME conflict

DMs	*Phase I*	*Phase II*	*Phase III*
Shell	1. Comply with federal requirements 2. Negotiate with OSEC	1. Continue the project	1. Accept the decision
OSEC	3. Request public hearing 4. Negotiate with Shell	2. Against the project	2. Protest
ERCB	5. Hold public hearing	—	—
JRP	—	3. Approve the project 4. Modify the project 5. Reject the project	—
Federal Government	—	—	3. Agree the decision 4. Reject the decision

Table 2. Feasible States for Phase I

DMs	*Options*						
Shell	Comply	Y	N	Y	N	Y	N
	Negotiate	N	Y	N	Y	N	Y
OSEC	Request	Y	Y	Y	Y	N	N
	Negotiate	N	N	N	N	Y	Y
ERCB	Hearing	N	N	Y	Y	N	N
	State	1	2	3	4	5	6

Preferences are an important aspect in a conflict study. Option prioritizing [8] is a common technique to apply. It specifies preferences through assigning priorities to the preference statements in the model, the top statement has the highest priority and the last statement has the lowest priority. For example, in Phase I, Shell most prefers ERCB not hold a public hearing, next prefers to comply with the federal requirements. Shell's least important preference statement is to negotiate with OSEC. As obtained by using the option prioritization technique, Shell's preference ranking of states is: (5, 1, 6, 2, 3, 4). OSEC prefers to request a public hearing the most because Shell insists not to implement its commitments with OSEC. Then OSEC would like ERCB to hold a public hearing if OSEC requests one. OSEC also would like to negotiate if and only if Shell is willing to negotiate. OSEC's preference ranking of states is: (3, 4, 1, 2, 6, 5). ERCB's most preferred statement is that Shell and OSEC negotiate with each other. Next, it would like to hold a public hearing if and only if OSEC requests one. ERCB's preference ranking of states is: (6, 5, 4, 2, 3, 1). The same analysis is performed for Phase II and Phase III.

A state is stable for a DM if and only if the DM has no incentive to move away from the state. A state that is stable for all DMs is called an equilibrium. There are different types of stability definitions that are used to search for equilibria, including Nash Stability, General Metarationality, Symmetric Metarationality, Sequential Stability, Limited-move Stability, and Non-myopic Stability. An equilibrium provides a possible resolution to the conflict. The equilibria can be identified using the decision support system GMCR II [8, 9].

According to GMCR II, there are two equilibria for Phase I: a weak equilibrium (state 2) and a strong equilibrium (state 3). State 2 is stable for all stabilities except Nash stability. State 3 indicates that Shell chose to comply with the federal requirements. OSEC was disappointed and requested a new public hearing. ERCB decided to conduct a public hearing. Similarly, the single equilibrium for Phase II indicates that Shell preferred to continue the project while OSEC preferred to be against the project. JRP recommended a modification to the original project. In fact, these results were the actual situations that happened in September 2009 and July 2013, respectively.

Moreover, the results calculated by GMCR II indicate that there are two equilibria for Phase III. If the Federal Government rejects the project, Shell would not accept the decision while OSEC would glad to see this situation. If the Federal Government approves the project, OESC would be against the decision. In this case, the final result would depend on the preference of the Federal Government. In fact, the government approved the project in reality, which means that the government preferred the latter situation to the former one. A historical evolution of the dispute is illustrated in Fig. 2.

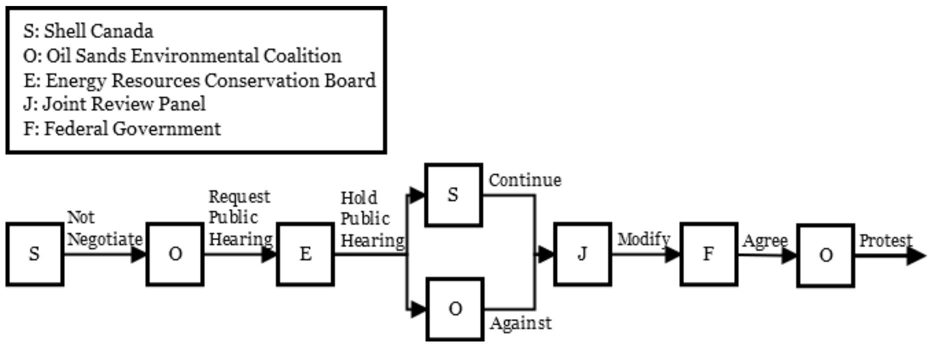

Fig. 2. Historical Evolution of the JPME conflict

4 Insights and Conclusions

Economic benefits and environmental damages are two important sides of the rapid expanded oil sands projects. A balance between these two sides would significantly benefit the sustainable energy future. According to the results predicted by GMCR, we can presume that the Federal Government of Canada cares more about economic benefits than environmental impacts. The position of the government results in massive protests and complainants from environmental organizations and Aboriginal people. The government should make sure that the oil sands projects are developed in a responsible manner and put more efforts on the environment conservation.

Moreover, a sensitivity analysis for Phase II suggests that there exists a certain DM who holds the balance of power (JRP in this case). Changes in the preference of this DM would vary the equilibrium of the conflict, while changes in the preferences of other DMs (Shell and OSEC) would not change the equilibrium. This information can be useful in understanding the role of each DM in a multi-participant decision making problem.

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Matrix Representation of a Hierarchical Water Diversion Conflict in China

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Abstract. The water diversion conflicts in China caused by the South North Water Diversion Project (SNWDP) are analyzed in a hierarchical structure. The hierarchical conflicts are modeled within the paradigm of the Graph Model for Conflict Resolution (GMCR) and represented in matrices to carry out calculation. Comprehensive resolutions based on the stability results provide possible courses of action for decision makers to follow.

Key words: water diversion, matrix representation, hierarchical conflict, graph model, conflict resolution

1 Introduction

To ease the severe water shortages in the North China Plain, the South North Water Diversion Project (SNWDP) has been proposed covering three locations. Conflicts arise with the implementation of this project. These conflicts are modeled in a hierarchical structure and within the paradigm of the Graph Model for Conflict Resolution (GMCR). Possible resolutions of the hierarchical conflict can be obtained to provide decision makers with courses of action to follow.

With 19% of the world's population and low water availability per capita, China suffers from frequent water shortages. In the North China Plain, severe droughts are caused by the increase of population and the decrease of precipitation. The increasing demand for water in industry and agriculture in the North China Plain worsens these water storages.

The South-North Water Diversion Project is designed to better utilize Chinas water resources. According to the project plan, water is diverted from the frequently flooded Yangtze River Basin to the dry North China Plain. This huge project consists of three main routes, Eastern, Central, and Western, as shown in Fig.1. As the project could have significant impacts on local societies and their environment, disputes among stakeholders, such as provincial governments and residents, arise on the three routes.

Fig. 1. The three routes of the South-North Water Diversion Project (Source: http://francistopia.edublogs.org/2011/06/03/south-north-water-diversion-project/, 2011)

Water diversion has been an important area of research from several perspectives. Interbasin water diversion projects in Brazil have been compared with two relevant projects: the Colorado-Big Thompson Project in the US and another in Australia [1]. Environmental, political, and economic complexities are often associated with these interbasin water diversion plans. Disputes caused by water diversions from the North American Great Lakes were investigated using game theory [3]. For SNWDP, water shortages were evaluated in areas around the Danjiangkou Reservoir [6]. A flexible water storage limit was set to allocate water effectively in the Yellow River Basin [16].

Methodologies to deal with conflicts have been developed, such as Game Theory [17], Metagame analysis [8], Conflict Analysis [5], Drama Theory [9], and Graph Model for Conflict Resolution (GMCR) [4]. In particular, GMCR has a flexible structure to model conflicts and can provide meaningful analytical results [14]. The basic components of a graph model include a set of decision makers (DMs), possible states, movements among states, and the relative preferences of each DM [4]. The matrix representation of a graph model was proposed by Xu et al. [18, 19]. It is an effective way of expressing conflicts and carrying out necessary calculations. Other studies on the graph model include coalition analysis [11, 12, 13], preference uncertainty [15], strength of preference [7], and Fuzzy preferences [2, 10].

The objective of the present study is to represent the hierarchical graph model in matrix form to investigate strategies in the water diversion conflicts in China. The analytical results indicate a comprehensive resolution for DMs to follow.

2 A basic Hierarchical Graph Model

A graph model for a strategic conflict contains a finite set of DMs, a finite set of feasible states, and preference relations for each DM. A hierarchical graph model consists of more than one smaller graph models, each of which represents a subconflict. A basic hierarchical graph model contains two smaller graph models, called subgraphs. In the basic hierarchical model, there is one common DM (CDM) who participates in both subconflicts. In each subgraph, the other DM besides CDM can only participate in the corresponding subconflict, which is defined as local DM (LDM). Thus, there are two LDMs and one CDM in a basic hierarchical model. The structure of this model is shown in Fig. 2, where a line represents an interaction between two DMs. The two LDMs are labeled as LDM_1 and LDM_2.

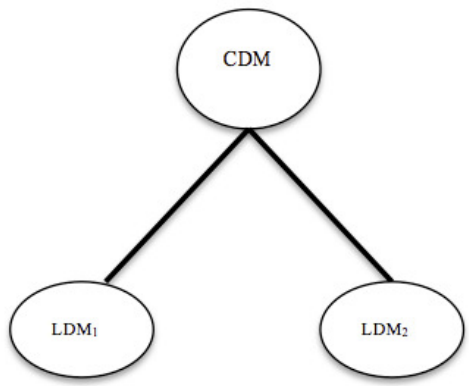

Fig. 2. Interaction among DMs in a basic hierarchical model

As CDM may consider one subgraph more important than the other, this priority is defined as subgraph importance for CDM. The preference relations for CDM are determined by its preferences in the two subgraphs and the subgraph importance.

3 Matrix Representation of Hierarchical Graph Model

In a graph model, possible moves among feasible states for each DM can be represented by a reachable list. The possible improvements among states for each DM can be denoted by a unilateral improvement list. The reachable list and unilateral improvement list can also be represented by reachability matrix and preference matrix.

The states in the hierarchical model are the Cartesian product of states in the subgraphs. Hence, the reachability matrix for CDM in the hierarchical graph can be defined as a tensor product of the two reachability matrices for CDM in subgraphs. With the information of subgraph importance, the hierarchical preference matrix for CDM can be constructed by two preference matrices for CDM in subgraphs. For each LDM in the basic hierarchical graph model, the hierarchical reachability matrix is expanded from the local reachability matrix. In this hierarchical reachability matrix, the entries representing the moves in the other subgraph should be zero. Similarly, the hierarchical preference matrix for each LDM can be obtained. Accordingly, Nash rationality (R), sequential stability (SEQ), general metarationality (GMR), and symmetric metarationality (SMR) can be determined by using the relationship between matrix elements and the state set in the hierarchical graph model [20].

4 Hierarchical Water Diversion Conflicts in China

As the eastern project is complete, conflicts arise on the central and western route and will affect the construction of the related projects. Local residents are affected by the construction on the central route. These residents oppose this project since they suffer from the relocation due to the inadequate compensation provided by the Central Government, in terms of providing subsidies, new residences, and job opportunities. As water will be diverted from some international rivers in the Tibetan Plateau, some neighboring countries show their concerns over the western project. They would protest this project and seek negotiations with Beijing.

The aforementioned conflicts are modeled in a basic hierarchical graph. The conflicts on the central and western routes are modeled by two subgraphs respectively. Chinese central government (CG) is CDM and local residents (LRs) and neighboring countries (NCs) are two LDMs, each of which is in the corresponding subgraph. As the western plan is still under discussion, CG considers the central conflict more important. The options and preferences for each DM are determined. Hence, the reachability and preference matrices for each DM in two subgraphs can be obtained. The hierarchical reachability and preference matrices for each DM can be constructed accordingly.

5 Stability Analysis

Four types of stabilities, Nash rationality (R), sequential stability (SEQ), general metarationality (GMR), and symmetric metarationality (SMR) in the hierarchical graph model are calculated with these hierarchical matrices. The equilibria that reflect possible outcomes of the hierarchical conflict are obtained. According to the analytical results, CG can carry out the projects on the central route regardless of opposition from LRs. However, on the western route, CG should suspend the projects in order to appease NCs. The difference in CG's resolution on two routes is caused by CGs priority over the central route. The two LDMs should also be inspired by the analytical results. Confronted with CGs strong determination in implementing the central projects, LRs should rethink their options to achieve a more favorable outcome. NCs are satisfied by the suspension of the western projects. However, they should still be alerted because CG may resume the projects once it sets priority on the western route.

6 Conclusions

To model the hierarchical conflicts caused by SNWDP, GMCR is extended to a basic hierarchical model consisting of two subgraphs. The hierarchical graph model is then represented in matrices to facilitate calculation. The reachable and preference matrices are constructed by the corresponding matrices in subgraphs. The analytical results reveal the resolutions for all DMs in the hierarchical conflict.

The basic hierarchical graph model can be further extended into a general hierarchical model with more than one CDM. It may also be possible to assume more subgraphs and LDMs in each subgraph. Coalitions among LDMs within a subgraph can also be investigated. The matrix representation on the general hierarchical model should be studied accordingly.

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The Preference Graph Model for Conflict Resolution

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Abstract. The Graph Model for Conflict Resolution provides a rich illustration of real life conflicts. In this paper, the Graph Model for Conflict Resolution is enhanced to provide the analyst with more in-depth information about an underlying conflict. This improvement is achieved by representing decision makers' preferences within the graph, which makes it possible to infer certain individual stability condition by glancing at the graph. A short background on modelling techniques for conflicts is given, including two types of stability properties that can be inferred from the graph.

Key words: conflict resolution, graph model, preferences

1 Introduction

Conflicts are a complex form of decision-making [12] in which two or more decision makers (DMs) pursue incompatible goals [5]. Game theoretic approaches provide the basis for modelling and analyzing conflicts. There is a number of ways to model conflicts, including the normal form, the extensive form, the option form, and the graph model for conflict resolution. Each modelling strategy conveys a particular amount of information based on its illustrative capacity. The normal form, for instance, is compact, easy to draw, and simple to read. However, it can only be used for small conflicts where the number of decision makers is limited to two or three. There is also a limited amount of information conveyed through the extensive form. The Graph Model for Conflict Resolution (GMCR), which can use the option form for notation, is the most comprehensive modelling approach for conflicts. It presents moves and countermoves only when they exist. GMCR can account for moves that are reversible or irreversible and common, and preferences that are either transitive or intransitive.

2 Background

In order to understand and analyze a conflict, different modelling techniques are used. The modelling of a conflict aims to provide in-depth understanding of a a conflict.

2.1 Conflict Resolution Models

A conflict resolution model is an abstraction of a real life conflict where two or more DMs are engaged in a dispute [2, 6, 7, 13]. Modelling conflicts falls under noncooperative game theory where DMs act independently [2, 8]. There are a number of ways to model a conflict: normal form [21], extensive form [18, 21], option form [9], and the graph model [2, 6, 7, 13].

The normal form is usually used to present a two-person game in a matrix, where the columns represent strategies available to one player, and the rows represent strategies available to the other. Each cell represents a combination of column and row strategy, which is useful to present compact games. In the normal form, all moves seem reversible, which is not always the case. An improvement over the normal form is the extensive form, which is a tree-like format that shows moves when they are available unilaterally. Nonetheless, because the extensive form branches out to show every possible move from each node, a conflict presented this way can be very large and hard to work with. In contrast, the option form, which uses a tabular format, can present large games [22], but lacks the ability to illustrate limitations in moves and countermoves. The option form is widely used to model conflicts [2, 9]. Finally, the graph model is the most advanced form to present moves that are possible for a DM, reversible, irreversible, or common. It also handles cardinal as well as ordinal preferences of DMs. The graph model can be used to present the moves of one DM, or combined to present the collective moves and countermoves of all DMs [2, 6, 7, 10, 11, 13, 16, 17].

2.2 Resolution Concepts

The resolution of a conflict is assumed to take place when the conflict becomes stable, as is assumed based on several sociological scenarios [2]. From DM's position in a conflict, systematic what-if questions can be asked to investigate the choices available. When all DMs find a certain scenario of a conflict acceptable, then this scenario is considered a possible resolution or equilibrium.

Individual Stability There are a number of stability concepts used in conflict resolution. Considering the preferences of DMs, their available moves and countermoves, stability definitions identify the likelihood of a state being accepted. For example, a DM who cannot unilaterally improve to a more preferred state, his or her state is considered stable for this particular DM. The previous example is called Nash stable (R) [19, 20]. However, a state that is stable for one player may not necessarily be stable for others. A resolution exists only when an equilibrium is reached, which happens when all DMs find the same state to be stable.

Other stability definitions include general metarationality (GMR) [9], symmetric metarationality (SMR) [9], sequential stability (SEQ) [3,4], limited-move stability (L_h) [15,17,23], and nonmyopic stability (NM) [1,14,15,17]. The foresight by which these stability definitions investigate what-if scenarios is different. In Nash stability, the oversight is considered low [2] because it considers only one move beyond present point. GMR and SEQ take into account one step further to examine countermoves, and SMR two steps. Limited-move stability has variable foresight; the analyst defines the horizon, or number of foreseeable steps. Finally, nonmyopic stability provides the highest level of foresight. It extends limited-move stability to take into account all possible steps beyond a certain state [2]. Nonetheless, both limited-move and nonmyopic stability assume transitive preferences.

2.3 The Graph Model for Conflict Resolution

For each decision maker, the Graph Model for Conflict Resolution consists of three main elements: feasible states, unilateral moves, and preferences. The Graph model for DM_i is $G_i = (S, A_i, \{\succ_i, \sim_i\})$ where G_i is the decision maker's i graph, S is the set of feasible states, A_i is the set of unilateral moves available for DM_i such that $A_i \subseteq S \times S$, and $\{\succ_i, \sim_i\}$ represents DM_is preference relation; for any $s, q \in S$, $s \succ_i q$ means state s is more preferred than state q, and $s \sim_i q$ means state s is indifferent to state q for DM_i.

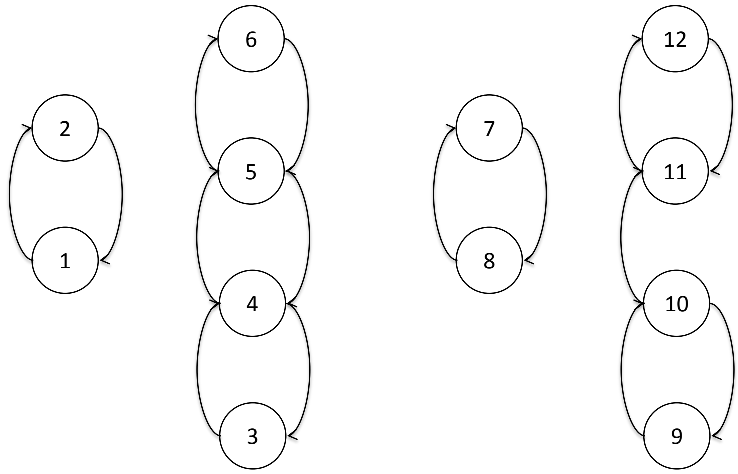
Consider the graph model for DM_1 given in Figure 1. There are twelve states $S = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$ and the preference relation for DM_1 is:

$$7 \succ_1 9 \succ_1 8 \succ_1 11 \succ_1 10 \succ_1 12 \succ_1 1 \sim_1 2 \sim_1 3 \sim_1 4 \sim_1 5 \sim_1 6 \tag{1}$$

In Figure 1, all elements of the graph are represented: states by numbered nodes referring to each feasible states', oriented arcs, which represent possible unilateral moves for DM_1, and finally preferences, which are written at the bottom of the graph. Although the preferences are written with the graph, they seem more like an attachment to the graph rather than an original element of the graph. This leads to the proposed improvement in the graph model, which is presented in the next section.

3 The Preference Graph Model

Utilizing the same illustrative example given in Section 2.3, the enhanced graph model as shown in Figure 2 represents the proposed developments in the graph model. Solid arcs represent preferred unilateral moves for DM_1. All solid arcs in this graph are reversible, except the move between node 10 and 11 where a vertical line crosses the solid arc, $\mapsto$ or $\nrightarrow$, which represent an irreversible move. The



Preference ranking = {7, 9, 8, 11, 10, 12, $\overline{1, 2, 3, 4, 5, 6}$}

Fig. 1. The Graph Model for DM_1

dashed arcs represent preferences but not actual moves. Thus, DM_1 would prefer to move from state 9 to 7 but cannot do so unilaterally. The combined nodes of $(1, 2)$ and $(3, 4, 5, 6)$ represent groups of equally preferred states, where DM_1 can unilaterally move within each group. The main advantage of the enhanced graph is that preferences are embedded in the graph, helping the analyst to find states that are stable for the decision maker. Moreover, knowing which moves are desired but not available to the decision maker can be used to understand the evolution of a conflict.

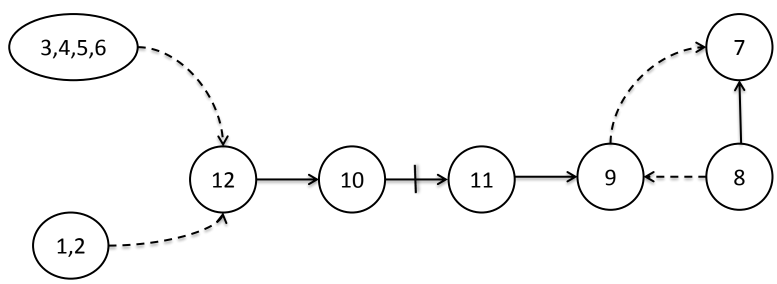


Fig. 2. The Preference Graph Model for DM_1

Therefore, changes are proposed to the original definition of graph model to introduce the preference graph model. The elements of the Preference Graph Model remain similar to the original graph. However, the oriented arcs no longer represent a unilateral move, but rather, a unilateral improvement. Hence, desired but not possible moves are represented by a dashed oriented arc to differentiate between an available and a desired but not possible unilateral move. Now, the Graph model for DM_i becomes $G_i = (S, A_i, V_i, U_i)$ where G_i is the decision maker's i graph, S is the set of feasible states, A_i is the set of reversible unilateral improvements available for DM_i such that $A_i \subseteq S \times S$, V_i is the set of irreversible unilateral improvements available for DM_i such that $V_i \subseteq S \times S$and U_i is the set of desired but not available moves such that $U_i \subseteq S \times S$, in symbols, $U_i = \{(s_1, s_2) \in S \times S : (s_1, s_2) \notin A_i \text{ and } s_2 \succ_i s_1\}$.

The Preference Graph Model can provide insights to stability analysis of individual decision makers. For example, in Figure 2 it can be inferred that DM_1 is Nash stable at states 7 and 9, because there is no unilateral improvements from these states. Moreover, in an integrated graph, which is not presented in this paper, the analyst will also be able to recognize states that are sequentially stable. Such advantages will simplify the analysis of conflicts using the Preference Graph Model for Conflict Resolution.

4 Conclusions

Embedding the preferences of a decision maker in the graph not only facilitated the understanding of unilateral improvements and desired moves, but also simplified the analysis and recognition of certain individual stability conditions. However, even though the preference graph in its current form does not account for intransitive preferences, most real life conflicts have transitive preferences. The original graph model can account for intransitive preferences by providing a list of pairwise comparison of all states attached to the graph. Finally, future work on the preference graph model will be needed to address intransitive preferences, and to define the integrated graph. Hence, the Preference Graph Model is recommended for transitive preferences only.

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A Proposed Methodology for Predicting Opponent Behaviour in Conflict Analysis

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Abstract. A modified Bayesian Affect Control Theory model is proposed to address the challenge of predicting opponent behaviour and preferences in conflict analysis. A crucial component of this approach is its ability to take into account the emotions of the parties in the conflict. The goal is to improve prediction and to satisfy an enduring challenge to conflict resolution methodologies.

Keywords: Affect Control Theory, Bayesian Affect Control Theory, Conflict Analysis, Emotions, Graph Model for Conflict Resolution, Partially Observable Markov Decision Process.

1 Introduction

The ability to predict opponent behaviour in conflict situations is extremely valuable for agents planning and strategizing future moves. In typical conflict situations, agents are aware of their own preferences and possible actions, but are uncertain about those of their opponents. Models such as Adversarial Intent Inferencing have been developed in order to remedy the informational asymmetry by providing a framework to dynamically capture and predict opponent goals and actions [11], [12]. However, these models fail to account for the emotions of the participants.

Conflict analysis literature has often highlighted the importance of emotions and attempted to account for them in conflict analysis methodologies [7], [8], [9]. Given that "central to any conflict are the emotional reactions that occur when opponents endeavour to manage, control, and cope with the situation" [9], models which do not recognize the role of emotions in agent-opponent exchanges are excluding a critical component of the interaction. What is needed is a predictive, dynamic model of opponent actions which accounts for emotions and their role in shaping behaviours.

2 Bayesian Affect Control Theory (Bayesact)

The proposed technique is a Bayesian Affect Control Theory (Bayesact) model adapted for conflict situations. Bayesact, described in [4], [5], rests on the principles of affect control theory (ACT) and is formulated as a partially observable Markov decision process (POMDP).

ACT is a social psychological theory which mathematically represents human interactions [2], [10]. Its core principle states that "people act to maintain the affective meanings that are evoked by a definition of a situation" [10]. The elements of an interaction are modelled in a three dimensional affective space whose basis vectors are Evaluation (good/bad), Potency (powerful/weak), and Activity (active/passive). Behaviours and emotions are indexed in the Evaluation-Potency-Action (EPA) space and interactions are modelled using an actor-behaviour-object syntax. The core principle of ACT dictates that the current state of an interaction is compared to a reference level and that the future behaviour is guided by the minimization of the difference between the two [10]. Studies in ACT, amongst them [3], have found that emotions predicted by ACT are usually close to the emotions that a person reports feeling in an event. Furthermore, individuals rarely report feeling an emotion that is far from the theoretical emotion predicted by ACT [3], [10]. ACT is thus a powerful way to model and to predict human interactions while accommodating the role of emotions.

Formally, POMDPs consist of sets S of states, O of observations, A of actions, a transition function T, an observation function Z, a reward function R, a horizon h, and a discount factor γ. POMDPs use modelling over probability distributions and Bayes' rule to infer and update a belief state which dictates a policy, or set of actions to maximize reward. With respect to predicting opponent behaviour, the most relevant function of Bayesact is its POMDP mechanism for predicting "how the affective state of an interaction will progress and how this will affect the object of the interaction" [4]. In other words, Bayesact both predicts opponent behaviour and provides the agent with a response strategy which maximizes expected utility.

3 Research Objectives

The aim of this research is to adapt Bayesact to conflict analysis interactions such that an agent is able to predict opponent behaviour and to respond with an optimal strategy. Ideally, this modified Bayesact could also be used to infer opponent preferences, thus bridging with the methodologies espoused in the graph model for conflict resolution [1],

[6]. The marriage of these two methodologies would provide the means for predicting opponent behaviour with emotions taken into consideration and allow for stability calculations using the graph model technique, which has proved to be a simple, flexible, and comprehensive methodology designed to analyze strategic conflicts. The prediction of opponent preferences would also help overcome the challenge of preference elicitation in the graph model paradigm.

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PART VII

Group Communication

How Does Internet and Social Media Use Impact Relationships? – Exploring University Student Perceptions

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Abstract. Relationships are central to our health and well-being and the use of technologies like Facebook is changing the way we communicate with others and manage our relationships. Excessive social media use can have a detrimental effect on family and intimate relationships, leading to mistrust, breakdown of relationships and potential legal disputes. This paper presents the results of a preliminary study focused on quantifying Australian university student use of the internet and social media and exploring student perceptions of the impact that social media use has on their relationships. Findings indicate that the majority of participants use the internet and social media frequently. Most students reported that they use social media to interact with family and friends and that it does not reduce the amount of time they spend speaking with family and friends overall. However, a quarter of students reported initiating friendships with people they had met online, a finding that warrants further research to explore the benefits and risks of such behaviour.

Keywords: Social media, Facebook, students, relationships, friendship.

1 Introduction

The use of computers and the internet across Australia has grown significantly in recent years [1, 2]. The types of devices Australians are using to access the internet is also changing. Instead of personal computers, increasingly, Australians are accessing the internet using smart phones [3]. The mobility of computing devices provides ease of access to information, but it also poses a challenge due to the attention given to mobile devices [4] as people grapple with managing their time spent on and offline [5].

Friendship, familial and intimate relationships, *the love needs,* are fundamental aspects of life [6, pp380-381]. Recent advances in technology are transforming the way we communicate with friends and family and how we make new friends. Social network sites, web sites that allow individuals to create an online profile and connect and interact with people they know or share similar interests with [7], have had just such an impact. They “satisfy the need for escape, for exploring, for interaction and socialization” [8, p68].

Social media describes a suite of sites, including social networks that provide the user with the ability to post content quickly and easily to a network of individuals online [9]. Recent figures indicate that social media use is popular among internet users in Australia [10]. Facebook and YouTube are the most popular platforms [11], with Facebook attracting nine million logins from Australians per day, which equates to almost forty per cent of the population [12].

Relationships are central to our health and well-being and the use of social media like Facebook is changing the way we communicate with others and manage our relationships. Excessive social media use can have a detrimental effect on family and intimate relationships, leading to mistrust, breakdown of relationships and potential legal disputes. The research presented here is concerned with quantifying the impact that social media has on relationships as a first step to developing a model for managing the impact of social media use on family life and relationships.

This preliminary study explores university student internet and social media use and their perceptions of how such usage impacts upon their relationships. It aims to build on existing studies in the field e.g. [13], providing an Australian perspective and a social media focus. The next section presents background literature that informed the study including the hypotheses that were used to frame the research. This is followed by the methodology and results of the study. The paper concludes with a discussion of the results with respect to the literature and a summary of findings and opportunities for future research.

2 Background

Social media allows individuals to stay in touch with friends and to potentially extend their friendship group [14]. A study by Ellison et al. [14] found that using Facebook was associated with enhanced social capital and an increased sense of well-being for university students. Valkenburg and Peter [15] associate the use of social media with enhanced self-esteem.

However, social media use has also been associated with depression and cyberbullying [15-17], cyber abuse [18] and problems with self-esteem [19, 20]. The use of social media applications can also lead to privacy concerns due to planned or accidental sharing of personal information, the systematic monitoring of information by third parties and identity theft [21].

Meeting people face to face after initiating a friendship online can place individuals, particularly youth and children at risk [22]. Young people are vulnerable to online predators and a range of cyber abuse [18]. However, some research indicates that relationships formed online that then translate offline can be beneficial and stronger than those forged face to face [23]. The ability to connect with others who share interests and concerns and being able to overcome real world impediments to initiating friendships such as shyness provide some with the opportunity to create meaningful connections online [23, 24].

Recent research by Relationships Australia Victoria [25], a leading Australian mediation and counselling provider, found that internet and social media use was playing a negative role in developing and maintaining relationships; a trend echoed in recent American research from the Pew Internet Research Center [13]. Specific concerns included individuals significantly reducing the amount of time spent with their partner due to high internet use, monitoring of partners activities and stalking of ex-partners [25].

Much of the research on the effects of internet use on personal relationships conducted in the 1990s concluded that internet use detracted from time spent interacting with family and friends face to face e.g. [26]; a reduction [27-29] or displacement [15, 30] hypothesis. This contrasts with more recent research that posits that internet use enhances interaction with friends and family; a stimulation hypothesis [15, 28-30]. These two hypotheses will be used to frame the interpretation of the results of this study.

3 Methodology

An exploratory case study method was adopted for this initial study to familiarize the researchers with the domain in preparation for future research [31]. Such a method is useful when exploring a "a contemporary phenomenon in depth and within its real-life context" [32, p18]. A voluntary, anonymous, online descriptive survey was used to gather data. The study targeted students enrolled in a compulsory IT subject as part of their undergraduate Bachelor of Business degree at Victoria University, in Australia. The subject was considered to be appropriate as a cross section of university business students take the subject each semester. Importantly, the survey was relevant to the subject selected, which covers basic IT for business concepts, including web 2.0, e-commerce and social media. Consequently, the respondents are computer literate and used to working and communicating in the online environment.

The students were invited to participate via an announcement in lectures and the subject web site. The survey was managed via Survey Monkey™ and students accessed the survey via a link on the subject web site. It consisted of single and multi-answer check-list questions, some of which had follow up short answer questions to elicit explanations and to provide context for student responses.

Descriptive statistics [33] were used to present results for analysis to enable identification of emergent themes [34]. These results were analysed with respect to the reduction [27-29] and stimulation [28-30] hypotheses. In addition, short answer responses were classified to identify key themes in responses.

The research presented is based on a convenience sample of university students at one location studying a specific degree. Therefore the results are presented are not claimed to be representative, nor are they necessarily generalizable. Rather they are presented to provide an initial snapshot of current usage trends and perceptions in the respondent group.

4 Results

There were a total of eighty seven responses to the survey. Fifty six per cent of respondents were female and forty four per cent were male. Ninety per cent of respondents were local students with only ten per cent international students. The majority of respondents were aged between nineteen and twenty one years of age (68%). The majority of the remainder were in their twenties.

Respondents were asked to identify how many hours a week they used the internet. The results, depicted in Table 1 below indicate a significant amount of time is spent online for many respondents, with almost thirty two per cent indicating they spend 20 or more hours online every week.

Table 1. Hours spent using the internet per week.

Answer Options	Response Percent
Less than 1 hour	1%
1 hour - 4 hours	6%
5 hours – 8 hours	19%
9 hours – 12 hours	25%
13 hours – 20 hours	17%
20 hours+	32%

Respondents were asked how frequently they used Facebook. Over half of the respondents (54%) indicated that they were always logged on. Most of the remaining respondents indicated they used Facebook several times a day.

Mobile phones (94%) or personal laptops (93%) are the primary means used by respondents to access the internet. Students report using public computers at school, libraries and other venues (84%), tablets to a lesser degree (51%), followed by home PCs (36%).

Respondents indicated that they used a variety of social media. Facebook was almost universally used, with almost ninety nine per cent of respondents indicating they used it, followed by YouTube, with eighty four per cent of respondents using it, as shown in Table 2.

Table 2. Social Media used by students.

Social Media	Percentage	Social Media	Percentage	Social Media	Percentage
Facebook	99%	LinkedIn	23%	Omegle	2%
YouTube	84%	Whatsapp	23%	RSVP	1%
Instagram	55%	Tumbler	16%	Oovoo	1%
Skype	48%	Vine	16%	I don’t	1%
SnapChat	44%	Blog	10%	Other	9%
Twitter	39%	Kik	9%		

One question explored why respondents used social media. Almost all of the respondents indicated that it was to keep in contact with friends and family (96%), many used it to be aware of and follow family/friends (67%), followed by reconnecting with friends from the past (51%). Another significant motivator was making new friends (26%).

Respondents were asked to indicate whether using the internet had changed the amount of time they spent speaking to friends and family. Forty six per cent of respondents indicated that it had increased the amount of time spent speaking to friends and family. Forty seven per cent indicated that there had been no change and only seven per cent indicated that using the internet had decreased the amount of time spent speaking to friends and family.

Finally, respondents were asked if they had had offline friendships and relationships with people that they had initially met online. A third of respondents indicated that they had made a friend via social media and then met up with them in offline. Thirteen per cent had been in an intimate relationship with someone that they had met online.

Meeting up with people offline after becoming friends online produced some polar feedback via short answer questions on the topic. For those who had forged friendships online, they felt it wasn't that different to making friends in a face to face environment. As one noted *"we had already called each other on Skype and on the phone, it wasn't all that different"*. Another commented, *"I met quite a few people in a support group for chronic illness so we had a lot in common and it was great to meet other people with similar battles."* For those who had been in a relationship with someone they had met online a couple noted that it had not lasted due to physical distances. However, others felt that it was an enjoyable experience. As one student noted, *"it's wonderful, you can get to know them really well and there are less nerves involved…"*

However, the idea of initiating friendships online for the majority of students was a cause for mild concern through to alarm. The majority of feedback came down to concern for personal safety. As one student noted, *"…it could be dangerous"* and another pointed out *"…it's creepy."*

5 Discussion

The results showed that respondents are spending a significant amount of their time online, almost a day a week for many students. Working in the online environment is required to complete their studies, which may account for the figures reported. However, recent figures on Australian weekly internet use tally with the levels reported by the students [35].

A common method for accessing the internet was via a mobile device; Laptops at ninety three per cent were slightly preferred over mobile phones at ninety two per cent. Research by Nie, Hillygus and Erbring [36], found that the place and timing of internet usage relates to the impact it has on relationships. Specifically, work based internet use has less of an impact on relationships than home based use on the weekends; time that might normally be spent interacting face to face with family and friends [36]. This shift to mobile access represents an interesting phenomenon that requires further research to explore the impact that mobile internet use has on relationships.

Facebook and YouTube are cited as the most popular social media sites used by respondents, matching Australian usage figures [11]. Facebook use was significant amongst respondents with over half reporting that they were constantly logged in to Facebook throughout the day. Just over twenty per cent of respondents indicated that they logged in between four to ten times a day. These figures are consistent with the findings from other studies focused on University students e.g. [21].

One third of respondents reported using Facebook to initiate new friendships. A small percentage of respondents indicated that they had had an offline friendship or relationship with someone that they had initially met online. While no respondents reported experiencing cyber abuse [18] or other risks identified in the literature [5, 17, 22] when meeting online friends in an offline environment, questions in future surveys will specifically explore these issues in more depth.

The use of social media to primarily interact with family and offline friends echoes previous studies [21]. This trend may relate to the student's perceptions of the impact that their Facebook had on their relationships; almost half of the students felt that using social media increased the amount of time spent speaking with family and friends. An additional forty seven per cent did not feel that social media use had changed the amount they spoke to friends and family. This is in contrast with earlier research that posited that time spent online, was time spent alone and thus directly reduced the amount of time interacting with others [36]. Rather, it seems that students are integrating online and offline interactions [37] when reflecting on the amount of time spent speaking to friends and family.

These results indicate that for the majority of students surveyed, the stimulation hypothesis applies. The majority of students appear to believe that social media and internet use enhances their relationships rather than detracts from them. However, a minority, seven per cent, did feel that the time they spent online reduced the amount of time spent speaking with friends and family, supporting a reduction hypothesis in some instances which requires further exploration.

6 Conclusion and future work

The results of this initial study provide support for the stimulation hypothesis. The majority of respondents indicated that they used Facebook several times a day to stay in touch with friends and family. Despite significant internet and social media use, the majority of respondents did not feel it reduced the amount of time spent speaking to friends and family overall.

However, a small minority of students felt that it did detract from face to face relationships. In addition a third of students reported meeting online friends in an offline setting. These findings alongside the impact of mobile internet use on our relationships have emerged as areas of focus for further research.

This preliminary study has provided some insights into how Australian university students are engaging in relationships via social media. However, further work is required to deepen understanding of the impact that internet and social media use has on relationships in the Australian context. A detailed national survey is planned for mid-2014 which will gather data to provide insights into the impact of fixed and mobile internet and social media use on relationships for the broader Australian population. Future work will also explore key issues like the impact of internet and social media use on negotiation skills and empathy as well as the use of social media by separating parents and its impact on children and the separation process.

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The Use of Circular Questions in Mediations

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Abstract. This experimental research investigated the effect of circular questions in face-to-face mediations on the mutual understanding and interpersonal trust between disputants, and on the satisfaction of the disputants with the outcome of the mediation. Our study showed that mediation 'works': after the mediation, the interpersonal trust of disputants and the mutual understanding between disputants was significantly higher than before the mediation. However, no effects were found of circular questioning on the improvement of mutual understanding and interpersonal trust from before to after the mediation session.

Keywords: Face-to-Face Mediation, Mutual Understanding, Interpersonal Trust, Circular Questioning.

1 Introduction

Disputants ask for a mediator when they cannot solve their differences themselves. When disputants enter a mediation session, they are often unwilling or simply unable to take the perspective of their counterpart and to reflect on their actions. One of the mediator's most important tasks is to help his clients just to take that other perspective [1]. In order to reach that objective, mediators can apply the communication technique of circular questioning. By asking a quarreling neighbor question like: "How do you think your neighbor will react to your insults?", the addressee is obliged to think about the effect his behavior has on his neighbor [1]. Hence, in each circular question lies an implicit request for understanding the other. On the contrary, an open question such as "Mary, how do you feel about the broken glass?" only enables Mary to vent her own thoughts and feelings, without forcing her to take on the perspective of her counterpart.

In addition, circular questions also address reciprocity and they invite disputants to take each their responsibility for the conflict [2]. Since both disputants are responsible for the conflict, they are also both responsible for its solution. For example, an circular question like "John, what do you think that Mary needs from you in order to fulfill your wish of keeping the shared front yard clean?", forces John to think about ways to contribute to the dispute's solution that suits Mary, whereas an open question like "John, what do you need from Mary?" focuses only on what John needs from the other party and not on what the other party needs from him. By also asking the reciprocity question to the other party Mary, both disputants can reflect on the fact whether their counterpart has the right perspective of their personal needs, feelings and whishes.

The power of a circular question lies in the fact that perspective taking takes place right in the presence of the other party. Disputants see and hear the other party taking over their perspective and they judge their counterpart's level of correctness. These effective communication techniques help develop the interpersonal rapport between disputants [3], [4], which consists of physical closeness, mutual attention, friendliness and spontaneous communication. The development of interpersonal rapport between disputants reduces tensions and facilitates the construction of mutual understanding (e.g. the feeling of being understood and understanding the other party) and interpersonal trust (e.g. the feeling of being trusted and trusting the other). Both mutual understanding and interpersonal trust are important factors influencing disputants' satisfaction with the outcome [1], [5], [6]. In addition, these factors also influence how mutual beneficial the outcome is perceived to be [3]. Although it is assumed that circular questioning has a powerful influence on establishing understanding and trust between disputants, empirical tests of the assumed relation in a mediation setting are yet to be performed. Therefore, this research aims at clarifying that relation. The following hypotheses will be tested:

H1 The use of circular questions by a mediator will increase the level of mutual understanding between the disputants, compared to using open questions.

H2 The use of circular questions by a mediator will increase the level of interpersonal trust of the disputants.

H3 A mediator using circular questions will be found to be more trustworthy, professional and impartial than a mediator who uses open questions only.

H4 A higher mutual understanding between disputants after the mediation leads to a greater satisfaction with the negotiated results.

H5 A higher interpersonal trust between disputants after the mediation increases the satisfaction with the negotiated results.

H6 The use of circular questions by a mediator will increase the level of mutual satisfaction with the negotiated results: circular questions will increase the feeling that a settlement is beneficial for both parties.

2 Method

2.1 Participants and Design

The experimental design had one manipulation, namely question mode (open vs. circular) as a between subject factor. Forty participants, all bachelor students from the department of Communication and Information Sciences at Tilburg University participated in the study.

2.2 Confederates and Conflict Scenario

In each mediation setting, one participant and one confederate were invited. Seven different confederates (three males and four females) took part in the study. Out of these seven confederates, five were members of the Tilburg University drama club. All confederates were trained to take part in the study and were asked to act consistently in all sessions. All confederates were paid €5,- per session and played the role of the same neighbor in all sessions. In addition, one professional, NMI[1]-certified mediator (male) and two trained mediators (females) were invited to mediate the disputes. The trained mediators followed a two-day NMI certified course in “Applying Mediation Skills”. In this way, real-life mediation sessions could be simulated. The conflict scenario used was a neighbor’s quarrel, describing a conflict between a student (participants’ role) and their full-time working neighbor (confederates’ role).

[1] The Netherlands Mediation Institute (NMI) is a national mediation platform in the Netherlands that assures the quality of its registered mediators.

2.3 Procedure of the Mediations

Before the mediation started, participants were invited in a separate room in which they could not meet the confederate. Subsequently, they were handed a conflict scenario of the neighbors' quarrel in which the participant was only confronted with the student's version of the conflict. After having read the scenarios, participants were told they had to negotiate with their neighbor, that they would be assisted by a mediator, that they wanted to attain certain goals (described in the scenario), that they also wanted to have a good relationship with their neighbor in the future, and that there was no time pressure, although the experiment leader would ask the parties to wrap up the mediation after thirty minutes. After the mediation session, participants were asked to fill out a questionnaire.

2.4 Questionnaire

The questionnaire measured (1) whether a result was reached (yes/no), (2) the satisfaction level of both parties, (3) how mutual beneficial the outcome was perceived to be, (4) the mutual understanding between parties (before and after the mediation), (5) the interpersonal trust between parties (before, during and after the mediation), and (6) the trustworthiness, (7) professionalism and (8) perceived impartiality of the mediator. For these measurements, an adapted version of the Organizational Trust Inventory – Short Form (OTI-SF) created by Naquin and Paulson [7] was used, who adjusted the OTI-SF scale so that it would be more appropriate for negotiation settings. The items measuring the affective and cognitive components of all three dimensions of trust (i.e. reliability, honesty and good faith in the fulfillment of the counterpart's commitments) [7] were supplemented with items concerning the professionalism, trustworthiness and partiality of the mediator, items concerning disputants' satisfaction with the outcome, and items concerning disputants' mutual understanding. For these constructs, 49 seven-point scales were made. All constructs had a high reliability, Cronbach's α ranged from .69 to .89.

3 Results

Factorial ANOVAs for Repeated Measures were run to test for the effect of Question Type (circular vs. open) on Feeling Understood (before and after the mediation) and on Understanding (before a**n**d after the mediation). The means are presented in table 1.

Table 1. Question Type (Open vs. Circular) in Relation to Feeling Understood and Understanding (1 = minimum, 7 = maximum; SD between parentheses)

	Feeling Understood		Understanding	
	Before	After	Before	After
Open	1.98 (0.66)	4.60 (1.23)	2.96 (1.00)	5.35 (0.64)
Circular	2.11 (1.04)	5.19 (1.02)	2.66 (1.07)	5.58 (0.68)

Significant main effects were found for Feeling Understood, F (1, 37) = 39.49, p < .001, and for Understanding, F (1, 37) = 165.74, p < .001, indicating that scores on these measures increased from before to after the mediation irrespectively from Question Type used by the mediator.

There was no significant main effect of Question Type, F (1, 37) = 0.91, p = .347, indicating that open and circular questions did not differ in their effect on Feeling Understood nor on Understanding. However, there was a marginally significant interaction between Question Type and Feeling Understood before and after the mediation, F (1, 37) = 3.47, p = .071. The feeling of being understood tended to improve more after circular questions, M_{before} = 2.11, SD = 1.04; M_{after} = 5.19, SD = 1.02, compared to open questions, M_{before} = 1.98, SD = 0.66; M_{after} = 4.60, SD = 1.23.

The second analysis investigated the interaction effect of Question Type (circular vs. open) on Feeling Trusted (before, during and after the mediation) and Trust in the Other (before, during and after the mediation). The means are presented in table 2.

Table 2. Question Type in Relation to Feeling Trusted and Trust in the Other (1 = minimum, 7 = maximum; SD between parentheses).

	Feeling Trusted			Trust in the Other		
	Before	During	After	Before	During	After
Open	2.50	5.34	4.92	2.13	4.57	4.35
	(1.18)	(0.93)	(1.13)	(0.88)	(1.16)	(1.35)
Circular	2.13	5.45	5.07	2.00	4.93	4.79
	(1.14)	(0.78)	(0.83)	(0.98)	(0.86)	(1.14)

There were main effects for Feeling Trusted, F (1.35, 51.09) = 128.36, p < .001, and Trust in the Other, F (1.38, 50.96) = 111.22, p < .001. Contrasts revealed that the ratings for Feeling Trusted before the mediation significantly improved during, F (1, 37) = 185.41, p < .001, and after the mediation, F (1, 38) = 116.96, p < .001. In addition, the ratings for Trust in the Other before the mediation significantly improved during, F (1, 37) = 145.06, p. < .001, and after the mediation, F (1, 37) = 107.99, p < .001. However, no significant interaction effects were found for Question Type on the three levels of Feeling Trusted, F (1.35, 51.09) = 0.95, p = .360, and on the three levels of Trust in the Other, F (1.38, 50.96) = 1.19, p = .299.

The third analysis tested the main effect of Question Type on the Professionalism, Trustworthiness and Partiality of the mediator. The means are presented in table 3.

Table 3. Question Type (Open vs. Circular) in Relation to the Professionalism, Trustworthiness and Partiality of the Mediator (1 = minimum, 7 = maximum; SD between parentheses).

	Professionalism	Trustworthiness	Partiality
Open	5.98 (0.77)	6.20 (0.71)	6.35 (0.62)
Circular	6.00 (0.84)	6.25 (0.55)	6.15 (1.03)

The analysis revealed non-significant results for Question Type on the Professionalism, F (1, 38) = 0.01, p = .922, Trustworthiness, F (1, 38) = 0.06, p = .805, and the Partiality of the mediator, F (1, 38) = 0.56, p = .460.

The fourth analysis tested the relationship between mutual understanding after the mediation and disputants' satisfaction with the outcome of the mediation. There were significant positive relationships between Feeling Understood and the Satisfaction With the Outcome, r = .50, p (one tailed) < .001, and between Understanding and the Satisfaction With the Outcome, r = .55, p (one tailed) < .001.

The fifth analysis investigated the relationship between the interpersonal trust after the mediation and disputants' satisfaction with the outcome. There were significant positive relationships between Feeling Trusted and the Satisfaction With the Outcome, r = .47, p (one-tailed) < .001, and between Trust in the Other and the Satisfaction With the Outcome, r = .55, p (one-tailed) < .001.

The last analysis looked at the main effect of Question Type on the Mutual Satisfaction of the Outcome (e.g. beneficial for both disputants). The means are presented in table 4.

Table 4. Question Type (Open vs. Circulair) in Relation to the Mutual Satisfaction, Personal Gain Only, Gain for Counterpart Only (1 = minimum, 7 = maximum; SD between parentheses).

	Mutual Satisfaction	Personal Gain Only	Gain For Counterpart Only
Open	5.80 (0.70)	4.50 (0.95)	3.55 (1.36)
Circular	5.90 (0.91)	4.60 (0.94)	3.35 (1.18)

The results showed that there were no significant main effects of Question Type on Mutually Beneficial, F (1, 38) = 0.15, p = .699, Personal Gain Only, F (1, 38) = 0.11, p = .739, and Gain For Counterpart Only, F (1, 38) = .25, p = .622.

4 Discussion

In general, mediation seems to ‘work’. The mutual understanding and interpersonal trust improved from before to after the mediation. Moreover, the improved mutual understanding and interpersonal trust made disputants more satisfied with the settlements they had reached. Further, the type of question (open vs. circular) tended to interact with the feeling of being understood, indicating that the feeling of being understood improved more from after a session of a mediator using circular questions, compared to open questions.

However, regardless whether disputants were confronted with open or circular questions, the feeling of understanding the other party, being trusted and trusting the other party was higher after the mediation than before the mediation. Furthermore, the type of questioning did not affect the mediators’ trustworthiness, professionalism or partiality, and the type of question did not have a significant effect on how mutually beneficial the outcome was perceived to be.

Although perspective taking would be beneficial in theory, we did not find empirical evidence for it. Does the theory not hold for mediation processes, or could other factors account for this result? We did find that disputants were much happier with the settlements they reached when their mutual understanding and interpersonal trust was higher. Establishing understanding and trust is thus important for the mediation process. Therefore, it could be that other factors accounted for the effect of circular questioning in the mediations.

A factor that could have accounted for the results is the naturalistic environment of our mediations. The realistic face-to-face settings and the presence of the mediator could have intensified the feeling of conflict. Disputants’ feeling of being wronged could have led them to resist empathizing with their counterpart. To examine whether this could have been the case in our mediation experiments, we will analyze the (non-)verbal behaviors of the disputants in the video-recordings of our mediation sessions.

Moreover, the timing of the circular question is very important for perspective taking. If a mediator asks a circular question too early in the process, then disputants will - reluctantly - answer the question, because they are not ready to take over the perspective of their counterpart. To the other party, this can come across as a forced understanding [6] and it may hamper disputants’ feeling of being understood. Our video-recordings may show whether the circular questions were asked too soon in the process.

Furthermore, although no circular questions where used in the open questioning conditions, it could be that other communicative techniques, such as summarizing, paraphrasing, or reflecting might have an influence on establishing understanding and trust. Future research might investigate the influence of these communication techniques on the mediation process and how they interact with circular questions.

Finally, although we examined naturalistic mediations, disputants still had to engage in a role. This could have influenced their initial and final feelings of mutual understanding and interpersonal trust, simply because they could not empathize with their role.

Future research might address this and the above mentioned issues by adjusting the experimental method. For instance, in future research we could test the perception of mutual understanding and interpersonal trust in a more quantitative manner, by – for example - letting participants read and interpret different mediation scenario's in which open versus circular questions are used by a mediator.

In addition, as a follow-up study, we are investigating the effect of the communication mode (online vs. face-to-face) on the mediation process and outcome. Because of the greater physical proximity, social, personal and non-verbal information exchange, and interpersonal rapport in face-to-face settings [8], [9], it has been argued that offline mediations (e.g. richer media) attain a higher level of interpersonal trust [10] and mutual understanding [11] between disputants compared to online mediations. Furthermore, it is believed that the loss of non-verbal cues disable mediators to set a professional, understanding, and trustworthy mediation setting [12], [13]. These assumptions, however, have not been tested experimentally in settings in which face-to-face and online mediations are directly compared. Moreover, the use of circular questions might improve the level of interpersonal trust and mutual understanding in online settings. In our follow-up study, we address these assumptions and investigate the effect of the communication mode on the mutual understanding, interpersonal trust, (mutual) satisfaction with the outcome, and the trustworthiness, professionalism and impartiality of the mediator. At the conference, we will report our initial findings.

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PART VIII

Group Decision Systems

Aiding the choice of a voting procedure for a business decision problem

Adiel Teixeira de Almeida and Hannu Nurmi

Abstract Since all voting procedures have some serious drawbacks that lead to undesirable outcomes under some circumstances, we aim to characterize decision settings that make certain performance criteria particularly pertinent, while at the same time rendering other criteria largely irrelevant. The settings are distinguishable in terms of the goals of group choice as well as of the assumptions one can reasonably impose on the individuals participating. In business organization the mcdm group decision process, considering final aggregation of DMs preference, usually uses voting procedure. However, a specific decision problem has to be accounted for in this situation. This problem consists of choosing the voting procedure. In this paper we assume that this decision should be made by the DMs with some methodological and technical aiding given by an analyst, using a specific decision model. Therefore, this paper presents some features related to an mcdm model for aiding the choice of a voting procedure for a business organization decision problem.

Keywords Choosing voting procedures; voting procedure properties; business organization decision context

1 Introduction

Although, one might think that voting procedures have been designed for political election rather than to a business decision in group context, these procedures are quite appropriate for a range of business decision problems. The range of business decision problems analyzed in this paper has a few characteristics, including the consideration of multiple objectives by each de-

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cision maker (DM). That is, a multi-criteria decision making (mcdm) process is faced by each DM.

In business organization the mcdm group decision process, except in situations related to negotiation process, may be of two kinds: a) initial aggregation of DMs preference; b) final aggregation of DMs preference. In the former the DMs share the same objectives and the criteria are aggregated in an integrated process. In the latter, the DMs may have different objectives and criteria and the integration amongst them is conducted over the alternative rankings given by each one of them separately.

For group decision processes considering final aggregation of DMs preference, voting procedure is a natural approach. However, another decision problem comes up in this situation, which is related to the choice of the voting procedure. Usually, this decision is based on technical issues associated to the characteristics and formal properties of the voting procedures. Although, this decision is not directly related to actual decision faced by the DMs and appears to be as one of the technical decisions alongside the process, we argue that this decision should be made by the DMs with some methodological and technical support. This paper is concerned with proposing an mcdm model for aiding the choice of a voting procedure for a business organization decision problem.

Also, in this study we aim to look at the circumstances of social choices from a another angle. We try to characterize some modal categories of choice situations in which certain performance criteria of choices would seem to be a crucial importance at the expense of others. We then list a few social choice rules that would be suitable for those types of circumstances in the sense of satisfying those desiderata that are crucial. Some of our circumstances pertain to the standard environments where each group member is assumed to be endowed with complete and transitive preference relations over the set of alternatives, but the goal of the procedure is assumed to be shared by all decisions makers. Some, in turn, are situations where the group members know nothing about each other's views. Another set of circumstances is one where the standard assumptions about preference relations simple aren't plausible, e.g. people may typically use different criteria in comparing some pairs of alternatives than in comparing some other pairs or they may exhibit preference reversals or incomplete preferences.

2 A model for aiding the choice of a voting procedure

The type of decision problem may have a great influence in the choice of the procedure. However, the main distinction, regarding the type of decision may not be related to the two kinds of decisions mentioned; that is: a business decision and a political election. The main issue which makes difference is related to either: choice of a person or choice of a policy. Both problems may be faced in business organizations, although the latter may be more regular and usually may be referred to as a choice of an alternative course of action; for instance, choosing a project. In business organizations the choice of a person may be rather related to selecting an employee (or a member of staff for occupation of some kind of function, for which specific skill are required) than choosing a representative of other people.

For choosing of such a procedure, two situations have to be considered. The first situation is related to choice of a procedure to be applied in every decision making process. This is a typical process of group decision on a board of any business organization. Normally, norms and formal procedures of the organization have to state which voting procedure should be applied. The second situation is associated to the choice of a procedure applied in a specific business decision problem in the organization. In this kind of situation, each decision problem requires differentiated considerations which may lead to a particular suitable procedure. The focus of this work is for the second situation, although an mcdm model for aiding the choice of a voting procedure should also be applied for the first kind of situation.

In the second situation, most of the cases, the decision makers (DMs) may have already made their own ranking of alternatives, before an aggregation procedure starts to be considered. The basic criteria for such kind of mcdm decision problem are basic properties of voting procedures and other characteristics, such as paradoxes that may be relevant to be considered in analyzing a voting procedure. A selection of a set of criteria consisting on the most relevant properties for the voting procedures may be considered (Nurmi, 1983; 1987). Also, the matrix of evaluation of these properties for the main voting procedures can be built. This matrix evaluation depends on the context of the decision problem and its scores have to be consistent with the mcdm method.

It is assumed that such an aiding process considers the participation of an analyst or facilitator, who has the role of support all DMs in the group decision process. One of the steps of the procedure requires that the analyst explain to the DMs the main voting procedures available and their main characteristics, as well as their behavior regarding to paradoxes and main properties related to such procedures. The analyst may adopt two different sequences for the decision process, as follows:

- DMs chooses the voting procedure first; that is, before the DMs make the ranking of alternatives.
- DMs chooses the voting procedure after all DMs have made the ranking of alternatives.

The second procedure is fine, if the DMs do not know the rankings of each other. The first process may lead to manipulation, by means of adopting strategic choices for the rankings.

3 Comparing voting procedures

The best-known results of modern social choice theory pertain to compatibility of various choice desiderata. Typically they aim to show that from a set of intuitively plausible principles of choice only a proper subset can be adhered to by any given rule under all circumstances. That circumstances are important for the incompatibility captured by Arrow's (1963) impossibility theorem has been pointed out by many authors. E.g. Black (1958) introduced the notion of single-peakedness to give a sufficient condition for the avoidance of the incompatibility. This notion turned out to be but one of several possible restrictions on the domain of preference profiles that would guarantee the satisfaction of Arrow's other conditions.

3.1 Non-strategic settings

Most of us most do our daily shopping by simply revealing our true preferences (given the budget restrictions) in selecting goods to our basket. It would seem that this also holds for our responses to most opinion surveys. Some voters (perhaps a vast majority of them) also reveal their true opinions in political elections. This is called expressive voting.

Although a variety of criteria for comparing voting systems has been introduced over the past decades, it would seem that two of them are of particular importance since they can be related to rationality. To wit, participation condition can be viewed as an individual rationality criterion since a failure on participation would conceivably confront an individual with a contingency where his vote would be harmful to his own interest in the sense that the outcome following from his abstinence would be better for him.

A similarly compelling and rationality-related criterion applicable in these circumstances is Pareto optimality. This can be viewed as a collective rationality criterion since it states that if each participant strictly prefers alternative x to alternative y, then y is not chosen. Clearly, a failure on Pareto optimality would be be collectively irrational.

Of somewhat more controversial nature are criteria connected with the name of Condorcet: the winner and loser criteria. The former dictates the choice of an alternative that would defeat all others in pairwise round-robin contests by a majority of votes. The latter, in turn, requires that an alternative that would lose against every other alternative in pairwise comparisons not be elected.

Of these two Condorcet criteria especially the former has been very commonly advocated as a plausible desideratum for social choice rules. Those rules that satisfy it do, however, not satisfy another plausible condition, viz. positional domination (Fishburn 1982). An alternative x positionally dominates alternative y, if for each of ranks $j = 2, \ldots, k$, the number of voters assigning x to rank j or higher is larger than the number of voters ranking y to rank j or higher. The positional dominance criterion dictates that those alternatives that are positionally dominated by some other alternative, not be chosen.

3.2 Strategic settings

In settings where the voters are primarily interested in the outcomes rather than expressing their opinions, the opinions expressed in balloting may deviate from the opinions held by the voters. Since the idea of taking a vote is to elicit the opinions of voters as accurately as possible, it would make sense to resort to systems where it is difficult to improve upon outcomes by misrepresenting one's opinions. But how to define this difficulty in an objective way? Successful preference misrepresentation requires information about the preferences (more precisely, expressed preferences) of other voters. One way of measuring the difficulty of misrepresentation is to ask how detailed knowledge of the overall profile one needs to succeed in misrepresentation. E.g. in plurality voting one typically needs only information about the distribution of votes over the first ranked alternatives. At the other extreme of difficulty is single transferable vote (see Bartholdi et al.). Similarly, Nanson's and Kemeny's rules would seem difficult to manipulate.

4 How to Deal with Voting Paradoxes

4.1 Dealing with intransitivity

It is not difficult to envision a setting where not only collective majority preferences but even individual ones could be intransitive (see, e.g. May 1954). Consider for example an individual who has been given the task of ranking three universities. In his opinion, three criteria of equal importance should determine the ranking: research excellence, quality of education and external impact. Suppose that in terms of the first criterion the ranking is ABC, in terms of the second BCA and in terms of the third CAB. Using pairwise comparisons and majority rule in determining the pairwise winners, one ends up with an intransitive ranking: ABCA... The occasional plausibility of intransitive individual preferences suggests that social choice rules could be based on pairwise comparison matrices representing individual opinions, i.e. $k \times k$ matrices with entry (i, j) equaling 1 if i'th alternative is viewed preferable to the j'th one, equalling 0 if j'th alternative is preferred to the i'th one.

This approach has, in fact, a long, albeit little known, history starting from Zermelo's (1929) seminal work.

Social choice rules can easily be defined using various tournament solution concepts: Pareto set, uncovered set, Copeland winners and the Banks set.

4.2 Dealing with incomplete preferences

Incomplete preferences can also be dealt with using the tournament apparatus. If an individual is unable to express preference between two alternatives i and j, the tournament matrix can accommodate this by inserting 0 into both the position (i, j) and (j, i). Incomplete tournaments have been the focus of some scholarly attention for a long time. E.g. Zermelo (1929) discussed chess tournaments with unequal number of contests between various pairs of players. The methodology devised for these settings is immediately applicable also in voting settings.

4.3 Dealing with other issues in voting

Many paradoxical observations of voting systems turn out to be aggregation paradoxes. Some of them, e.g. inconsistencies of choice, can be avoided by resorting to consistent procedures. Usually, however, avoiding one paradoxical contingency leads to another type of paradox. So, there are trade-offs to be made in dealing with paradoxes (see e.g. Nurmi 1987 for a summary).

5 A kind of MCDM method for comparing voting procedures

The are many mcdm methods, which may have a few different classifications. For the purpose of this study, some of these classifications may be useful. First, an mcdm method may be classified according to the action space, which can be either discrete of continuous. The former is of interest for the kind of problem analyzed. Another classification considers the form of compensation, if any, for aggregating the criteria. Two situations may be considered: compensatory and non-compensatory methods (Vincke, 1992; Figueira et al 2005). A number of methods may be included in the first type, for instance: MAUT (multi-attribute utility theory) and deterministic additive methods, such as AHP, SMARTS, MACBETH, among many others (Figueira et al 2005; Keeney and Raiffa, 1976). The latter includes lexicographical and outranking methods, such as: ELECTRE, PROMETHEE, among many others

(Figueira et al 2005; Vincke, 1992; Roy, 1996). A preference relation P is non-compensatory if the preference between two voting procedures x and y only depends on the subset of criteria in favor of x and y (Fishburn, 1976). Let $P(x, y) = \{i : x_i P_i y_i\}$, then:

$$\left\{ \begin{array}{l} P(x,y) = P(z,w) \\ P(y,x) = P(w,z) \end{array} \right\} \Rightarrow [xPy \Leftrightarrow zPw]$$

In this case, it does not matter how much is the performance of x or y in each criterion. An important consideration may be taken at this point with regard to the kind of rationality which would be more appropriate for the decision problem considered. That is, a voting procedure should be analyzed by a compensatory or non-compensatory approach? Some reflections may be provided regarding to which rationality would be more appropriate for the DMs in this particular decision problem. It is hard to consider the possibility of any DM analyzing any two properties or characteristics of a voting procedure, by making compensation between them. On the other hand, it seems reasonable to consider that a DM may analyze two properties or characteristics of a voting procedure, comparing them in terms of which would be more acceptable. Conversely, a DM could consider which of them would be more unsuitable for being present in a voting procedure. Therefore, it seems to be reasonable to assume that a non-compensatory method would be more appropriate to be applied in a specific decision problem

6 Conclusions

The study for building a decision model for aiding the choice of a voting procedure for a business decision problem is a working in progress in which the following main issues are being considered: the non-compensatory rationality; the sequence of the decision process; the set of relevant criteria; and the evaluation matrix of properties by voting procedures. The sequence of the decision process and the assumption of non-compensatory approach for the mcdm method can have a more detailed justification based on the characteristics and typical context of this kind of decision. The set of relevant criteria and the evaluation matrix of properties by voting procedures has already been suggested with several considerations to be included in the model (Nurmi, 1987).

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Introducing a Multi-criteria Group Decision Perspective into Enterprise Architecture Frameworks

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Abstract. Due to the complexity of the decision problems that enterprises are dealing with to became competitive in their markets, and the need to involve different point of views (inside and outside the organization), the numbers of decisions involving more than one person have been increasing over the last 20 or so years. Enterprise Architecture (EA) maps all software development processes, hardware and personnel within the organization, thus giving a holistic view of the whole organization and providing guidance for important enterprise concerns. This study proposes a framework to incorporate multi-criteria group decision approaches into EA frameworks.

Keywords: Enterprise architecture, EA framework, business-IT alignment, multi-criteria group decision making

1 Introduction

Organizations are investing in improving the alignment between their business and information technology (IT) activities in order to achieve the effective conduct of their business processes, especially because business is requiring more interaction between customers, partners and employees [1][2]. Technological changes such as business digitization, green computing, cloud computing, Web 2.0 and a future Web 3.0, are demanding changes in the management practices of enterprises and these will modify not only their IT infrastructure but also their policies, processes, and how their staff tackle their tasks [2]. Information technology enterprise architecture, in short Enterprise Architecture (EA), is a strategic information asset that describes and documents relationships among business/management processes and technology [1][3]. EA practitioners and enthusiasts advocate that EA approach can provide several benefits such as better IT operations by providing direction for the design, development and assessment of technological and managerial developments, thereby creating a coherent information infrastructure, reducing risk, improving scalability, etc.[1][4][5].

The level of EA maturity varies from one organization to the next. The levels of technology diffusion and dependence on technology have a direct relation with an organization's IS/IT maturity. According to [6], EA maturity has four stages: business silos, standardized technology, optimized core and business modularity. A company evolves through these stages as it (and its stakeholders) learn new organizational processes and change its IT investment practices. The more mature the company is, the greater the number of modular standards and repeatable processes it has. This may help to organize resources and plan future actions. By adopting an EA framework, a company provides a means to better understand the complexity of its business and its stakeholders' expectations, and also it supports decisions making about the future state of the organization and how best to communicate decisions taken [7]. Moreover the architecting process and decision making problems involve many stakeholders, whose perspectives and interests are diverse [7][8].

EA frameworks offer a guide to create and implement EA and several well-known examples of these are discussed in the literature [9]. Frameworks may specify a process, method or format of architecture activities and products. Actually, EA can also be supported by classical IT methods such as ITIL (Information Technology Infrastructure Library) [10][11] and COBIT (Control Objectives for Information and related Technology) [12], but EA frameworks are commonly used to organize enterprise architectures into different views that are meaningful to stakeholders. Some of the available EA frameworks were developed for very specific areas and proposals, whereas others have a broader functionality [13]. The five most discussed EA frameworks are: the Zachman Framework for Enterprise Architecture [14][15], DoDAF (Department of Defense Architecture Framework) [16], FEAF (Federal Enterprise Architecture Framework) [17], TEAF (Treasury Enterprise Architecture Framework) [18], and TOGAF (The Open Group Architectural Framework) [19].

The levels of complexity and responsibility for decisions which decision makers (DMs) deal with during the several phases of EA processes (selection, implementation, maintenance and updating) as well as consideration being given to different aspects of the areas of business, information, information systems (IS) and the technical infrastructure) have been stimulating a need to aggregate both the preferences of different DMs [20][21][22] and/or experts' knowledge [23]. In the context of EA the stakeholders may be architects, IT staff and business staff. Ref. [7] proposed a 4 by 4 matrix of EA stakeholders in which the columns represent the four EA aspect areas (business, information, information systems, technical infrastructure) and the rows represent the four organizational levels (Enterprise, Domain, Project, Operational). Undoubtedly, some of these stakeholders may act as DMs in certain EA problems. For instance, there may be a decision making problem involving a Business project manager, a Business process designer (both from a business/project cell), an Information analyst (from an Information/project cell), a data center manager (from a Technical Infrastructure/Operational cell) and an application manager (from an Information Systems/Operational cell).

Group decision making approaches and how they can improve problems of business effectiveness have been the focus of several studies which involve selecting an EA framework [24][25], the coordination of architecting work [26][27], collaborative processes [28][29] and business process redesign [30].

On analyzing the EA frameworks mentioned previously, we realized that although using them is widely encouraged by practitioners and academics, these methodologies do not explicitly consider a structured mechanism or procedure to aggregate decision makers' preferences in order to achieve a group decision that makes recommendations to solve an EA problem. Moreover, Ref. [1] argued that in order to have a well-coordinated architecting process, it is important to create conditions to support DMs with at least five cognition types: shared task knowledge, shared team knowledge, common ground, shared schemata, collective mind.

We argue in this study that faced with the new demands and challenges enterprises have to deal with, group decision-making processes regarding EA problems must not be too time-consuming. Group decision problems may consider several criteria, some of which may conflict with each other, and also the different perspectives of all DMs. Problem-structuring based on soft methodologies may not be suitable throughout the process because the group may not have the time to spare needed for this end nor may it be possible to arrange an *in loco* meeting. Multi-criteria group decision making approaches can be transversely incorporated into such EA frameworks and we discuss facilities and difficulties to implement these.

The next section presents the framework proposed and in Section 3 some remarks are drawn.

2 Framework proposed

In this study, first we set out a framework which consists of integrating multi-criteria group decision models with EA frameworks (see Fig. 1).

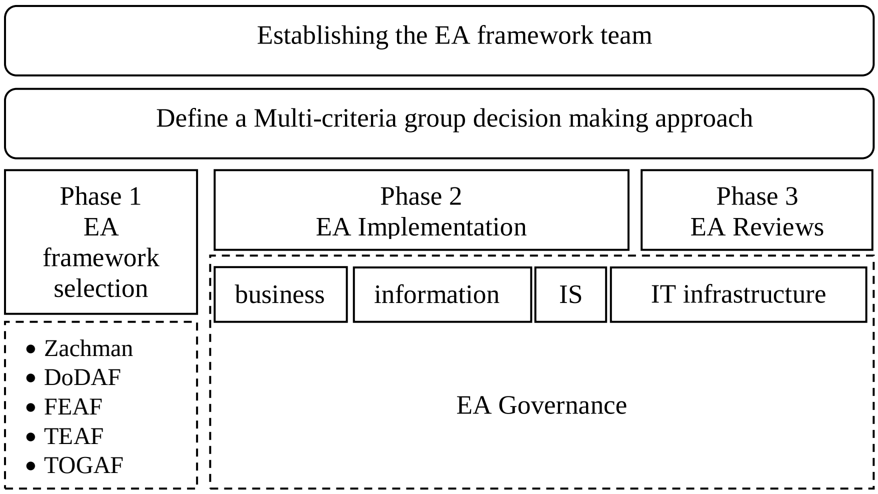

Fig. 1. Framework proposed

The development life cycle of the system is organized into three phases. Phase 1 represents the first stage of an EA problem which is to select an EA framework to be adopted by the enterprise. This selection may involve quantitative and qualitative criteria [3] [7] [25]. Five EA frameworks were analyzed in order to identify facilities and difficulties and to aggregate group decision making in their methodologies. Phase 2 involves all problems regarding planning, analysis and implementation in order to achieve an efficient business-IT alignment. This phase also includes making decisions on IT investments. Phase 3 represents the maintenance of EA success by reviewing the process, methods and products. Both phases 2 and 3 must be evaluated and managed in accordance with the area aspects (business, information, information systems and IT infrastructure).

Two research questions arise from the proposed framework: the first is how difficult is incorporating group decision perspectives into existing EA frameworks. The second question is how coordinate group decision activities throughout EA implementation. After having ascertained a context for the decision problem context and the DMs' preference structure, a suitable multi-criteria group decision model can be selected. Also depending on the decision problem context, the DMs involved in the EA implementation belonging to different areas of the company, such as the Business project manager, the Business process designer, the IT manager, the Information analyst, the Data center manager and so on.

3 Final Remarks

Due to the complexity of the decision problems that enterprises are dealing with to became competitive in their markets, and the need to involve different point of views (inside and outside the organization), the numbers of decisions involving more than one person has been increasing over the last 20 or so years. Multi-criteria group decision making models support a group of individuals to reach a collective final recommendation. In order to achieve efficient alignment between business and information technology (IT), questions involving aspects such as Information System Planning, Information Technology Governance, and Investment in Technology must be taken account [31].

Enterprise Architecture (EA) maps all software development processes, hardware and personnel within the organization, giving a holistic view of the whole organization and providing guidance for important concerns of the enterprise, such as business strategy, IT strategy, IT governance, and business-IT alignment. Architecture principles are means to achieve some strategic objectives. These objectives arise from business goals, enterprise architecture goals, IT goals, and the constraints which have to be faced.

This study investigated the most discussed EA frameworks in the literature and realized that they do not consider a well-structured process to support group decision making, especially with regard to qualitative or intangible criteria. Of the five EA frameworks studied TOGAF has support decision making in its methodology, although Zachman gives implicit information that in each cell of its ontology it is possible to consider group decision-making approaches and this structure may be useful for recursive decision-making problems involving a group of decision makers or experts.

Decision Support Systems (DSS) and also Work Collaborative Support Systems are important tools that allow DMs and stakeholders to reach common ground and share knowledge [32]. These computational tools give flexibility, agility and coordination to group decision making.

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PART IX

Preferences Aggregation

Determinants of Perceived Expertise in Group Problem Solving

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Abstract. Given the important functions perceived expertise has in problem solving groups, this piece of research focusses on its determinants. In addition to traditional determinant of perceived expertise (gender, age, and actual expertise), we examine the effects of more contemporary determinants, which are general self-efficacy, normative influence, and informational influence. We show that the more contemporary determinants explain a larger amount of the variance of perceived expertise. Specifically, exerting normative and informational influence during group discussions increases group members' perceived expertise.

Keywords: Perceived expertise, gender, age, actual expertise, general self-efficacy, group discussion, normative influence, informational influence.

1 Introduction

Perceived expertise is the extent to which individual group members are assumed to possess expertise. Why care about perceived expertise? Perceived expertise has at least two highly important functions in groups. First, it impacts the formation of leadership hierarchies in favor of those perceived to have high expertise [1]. Second, in order to make good decisions and solve difficult problems appropriately, groups need to be able to accurately recognize the expertise of their members [2] [3]. Therefore, it is important to examine the determinants of perceived expertise in groups [4].

Literature has shown that certain cues can act as determinants of perceived expertise in groups [5]. There are traditional determinants of perceived expertise, which have been frequently examined. In this piece of research we include three traditional determinants of perceived expertise, which are gender [6], age [7], and actual expertise [8]. Additionally, we include three contemporary determinants of perceived expertise, which have, to the best of our knowledge, not been considered as determinants of perceived expertise. These are general self-efficacy, normative influence, and informational influence. Our research model, which is formulated in accordance with input-process-output models [9], is depicted in figure 1.

Input	Process	Output
Gender Age Actual Expertise General Self-Efficacy	Normative Influence Informational Influence	Perceived Expertise

Figure 1. Research Model

2 Traditional Determinants of Perceived Expertise

We consider three traditional determinants of perceived expertise in groups. These are gender, age, and actual expertise.

2.1 Gender

Gender has been shown to reflect competence on many different tasks, and men are often perceived as more competent in performing a task [10]. Due to stereotypes, many decisions in organizations may trigger performance expectations in favor of men. Conversely, women are often perceived to possess lower expertise, even though men and women have been shown to have comparable levels of actual expertise [6]. Thus, we propose that men are perceived higher in expertise, as compared to women.

2.2 Age

The older a person is, the more experience the person normally has, which is associated with increased perceived expertise, especially in organization [7] [11]. Thus, we propose that age is positively related to perceived expertise.

2.3 Actual Expertise

Actual expertise is the expertise a person objectively possesses. In problem solving, actual expertise of group members is often conceptualized as the proximity of the group member's solution to an objectively correct solution [2]. It has been found that actual expertise predicts perceived expertise [8]. Thus, we propose that actual influence is positively related to perceived expertise.

3 Contemporary Determinants of Perceived Expertise

In addition to the traditional determinants of perceived expertise, there are some more contemporary determinants, including general self-efficacy and the group discussion content, specifically normative and informational influence group members exert during group discussion.

3.1 General Self-Efficacy

General self-efficacy is defined as *"individuals' perception of their ability to perform across a variety of situations"* [12, p.170]. Thus, self-efficacy is not a behavior, but an expectation to be able to perform a behavior. The positive impact of self-efficacy on performance is well documented in the literature [13] and self-efficacy is considered as a fundamental topic especially in the literature on organizational behavior [14]. People high in general self-efficacy have a larger self-esteem, are more confident in their ideas and actions, and consider themselves as capable to deal with many difficult situations in life [12], such as solving a complex problem. Therefore, given these properties of people high in general self-efficacy, we argue that the other group members attribute more expertise to those group members, as compared to those low in general self-efficacy. Thus, we propose that general self-efficacy is positively related to perceived expertise.

3.2 Normative and informational influence during the group discussion

According to [15], there a two types of social influence present in groups. These are normative influence and informational influence. Normative influence is defined as *"an influence to conform with the positive expectations of another"* [15, p.629]. Informational influence is defined as *"an influence to accept information obtained from another as evidence about reality"* [15, p.629]. During group discussions, normative influence is exerted through the conformity to group member's preferences and informational influence is exerted through arguments and information [16]. Specifically, statements that express a group member's preference, such as "Item 4 is the most important item.", are considered to generate normative influence [17]. Statements that express a group member's argument, such as "This item has many different functions.", are considered to generate informational influence [17]. In groups, normative and informational influence generally operate together, however, to varying degrees [16]. We argue that both normative influence and informational influence exerted by a group member during a group discussion are related to attributions of expertise to this group member. Given the nature of informational influence, we assume that informational influence exerted by a group member will be a better predictor for perceived expertise, as compared to normative influence. Thus, we propose that normative and informational influence are positively related to perceived expertise.

4 Study Design and Methodology

To test our research model, we ran a laboratory study with 100 business students (48 women and 52 men). In the pre group discussion part, the participants got a questionnaire in which they indicated their gender and age, and self-rated themselves on general self-efficacy. General self-efficacy was measured by the New General Self-Efficacy Scale [18] which has eight items (e.g. item 2: *"When facing difficult tasks, I am certain that I will accomplish them."* [18, p.79]) that are scored on a five-point Likert-type scale ranging from 1 (totally disagree) to 5 (totally agree). In our study, the eight items of the construct general self-efficacy show a highly satisfactory reliability (Cronbach's Alpha: .812). Next, participants had to indiviually work on a classical problem solving task, in which they had to rank 15 items (e.g. raincoat, knife) according to priority for survival in the desert [19]. The task has an objectively correct, however hard to verify, solution, which is common in business [20]. Actual expertise was measured by a Spearman rank correlation coefficient [21] between each individual ranking and the objectively correct expert ranking available for the task.

In the group discussion part, participants were randomly assigned to five-person groups, in which they had to work on the same ranking task again in a face-to-face group discussion, reaching an unanimous agreement. The group discussions were videotaped and, after the study, following [22], content coded, among others, for preferences statements (Cohen's Kappa: .86) and arguments (Cohen's Kappa: .79). Preferences statements correspond to normative influence, and arguments correspond to informational influence [17]. We calculated the relative number of preference statements for every group member in each group as measure of normative influence. We calculated the relative number of arguments for every group member in each group as measure of informational influence.

In the post group discussion part, participants rated each other on perceived expertise on a single item adapted from [7] with a seven point scale, ranging from 1 (very little expertise) to 7 (very much expertise). Those seven out of 100 participants that have performed the task or a comparable task before ($M = 4.32$) and those who have not ($M = 4.23$) do not significantly differ in perceived expertise, $F(1, 98) = .045$, ns..

5 Results

First, we test the determinants of perceived expertise, and second, we explore the relationship of (self-)perceived expertise, actual expertise, and gender.

5.1 The Determinants of Perceived Expertise

The means, standard deviations, and correlations of our variables are displayed in table 1.

	M	SD	1	2	3	4	5	6
1 Gender	.48	.50						
2 Age	23.78	3.82	-.113					
3 Actual Expertise	.31	.26	-.030	.174*				
4 General Self-Efficacy	34.08	3.33	-.241**	.163	-.066			
5 Normative Influence	.20	.10	-.108	.143	.061	.179*		
6 Informational Influence	.20	.11	-.210**	.238**	.266***	.369***	.639***	
7 Perceived Expertise	4.24	1.05	-.308***	.195*	.121	.445***	.519***	.665***

*** $p < .01$; ** $p < .05$; * $p < .10$; (2-tailed)

Table 1. Means, Standard Deviations, and Correlations (n = 100)

To test our models we ran a hierarchical multiple regression [23]. The results are shown in table 2.

	Perceived Expertise	Perceived Expertise	Perceived Expertise	Perceived Expertise
	Model 1	Model 2	Model 3	Model 4
Gender (0 = male; 1 = female)	-.290***	-.289***	-.200**	-.145*
Age	.162*	.148	.087	.015
Actual Expertise		.086	.125	.007
General Self-Efficacy			.391***	.221***
Normative Influence				.199**
Informational Influence				.411***
R^2	.121	.128	.268	.519
Adj. R^2	.103	.101	.237	.488
ΔR^2		.007	.140	.251
Sig. F-change		.374	.000	.000
F-value	$F(2, 97) =$ 6.666***	$F(3, 96) =$ 4.701***	$F(4, 95) =$ 8.685***	$F(6, 93) =$ 16.723***

Values are standardized beta-coefficients.

*** $p < .01$; ** $p < .05$; * $p < .10$

Table 2. Multiple Regression: Perceived Expertise

Our results show, that when only gender and age are entered as predictors, i.e. model 1, gender is negatively, $t(97) = -3.022$, $p < .01$, and age is positively, $t(97) = .1696$, $p < .10$, related to perceived expertise. When actual expertise is entered in model 2, it is non-significant, $t(96) = .893$, ns., gender stays significant, $t(96) = -3.008$, $p < .01$, and age becomes non-significant, $t(96) = 1.516$, ns.. When general self-efficacy is entered in model 3, it is significant, $t(95) = 4.257$, $p < .01$, gender stays significant, $t(95) = -2.205$, $p < .05$, and age ($t(95) = .957$, ns.) and actual expertise ($t(95) = 1.400$, ns.) remain non-significant. When normative and informational influence are entered in model 4, both normative influence ($t(93) = 2.088$, $p < .05$) and informational influence ($t(93) = 3.842$, $p < .01$) are significant, gender ($t(93) = -1.936$, $p < .10$) and general self-efficacy (t (93) = 2.738, $p < .01$) remain significant, and age (t (93) = .204, ns.) and actual expertise (t (93) = .090, ns.) remain non-significant. As evidenced by the increase in R^2, normative and informational influence add most in explaining the variance of perceived expertise, followed by general self-efficacy.

5.2 The Relationship of (Self-)Perceived Expertise, Actual Expertise, and Gender

Perceived expertise has been rated by the four group members. However, participants also rated their own expertise, i.e. their self-perceived expertise. Self-perceived expertise and perceived expertise are positively correlated, $r = .459$, $p < .01$. However, neither self-perceived expertise ($r = -.049$, ns.) nor perceived expertise ($r = .121$, ns.) are significantly correlated to actual expertise. As evidenced by three ANOVAs, even though men ($M = .32$) and women ($M = .30$) do not significantly differ in actual expertise, $F(1, 98) = .090$, ns., men ($M = 4.67$) perceive their own expertise, i.e. self-perceived expertise, higher than women ($M = 3.96$), as evidenced by $F(1, 98) = 11.427$, $p < .01$. Furthermore, men ($M = 4.55$) are perceived as higher in expertise by their group members, as compared to women ($M= 3.91$), as evidenced by $F(1, 98) = 10.260$, $p < .01$.

6 Discussion

Given the importance of perceived expertise for the formation of leadership hierarchies and for the quality of group decisions, we examined the determinants of perceived expertise. We have shown that from the traditional determinants, gender is the only significant one. That is, women, as compared to men, are perceived as lower in expertise by their group members. This is also consistent with the self-perception of women with regard to expertise. It might be that women are more humble and behave more cautiously in groups solving complex problems. However, women and men do not differ in actual expertise. Furthermore, we did not find a significant effect of age on perceived expertise, which could be due to the fact that our sample consisted of students which do not differ too much on age. However, an effect of age on perceived expertise is supposed to exist in groups with larger age differences. Surprisingly, actual expertise is not significantly related to perceived expertise. That is, in our study, group members were not able to recognize group members' actual expertise, which is consistent with [24].

Most importantly, our results confirm the importance of more contemporary determinants of perceived expertise. First, we have shown that general self-efficacy is positively related to perceived expertise. That is, the more a person holds the belief to be able to successfully master many difficult situations, the more the other group members perceive this person to be high in expertise. Second, we have shown that individual discussion content, specifically normative and informational influence exerted during group discussions, leads to higher perceived expertise. Hereby, consistent with our theoretical considerations, exerting informational influence, has a larger effect on attributions of expertise, as compared to normative influence. Thus, the more a group member exerts informational influence via arguments, the higher the other group members rate this member on perceived expertise. In addition, it has to be noted that the effect of gender on perceived expertise is clearly reduced, once normative and informational influence are also included as predictors of perceived expertise.

There are at least three areas of future research. First, our study, which was carried out in a controlled laboratory, used groups composed of members having comparable status and basically being not familiar to each other. Therefore, future research should examine the attribution of expertise in problem solving group in organizations in which members differ in status. If such groups have been working together for a certain period, high cohesion among group members is likely and that tends to result in high pressure towards conformity [25]. This might distort the perceptions of expertise, especially on a specific task. Second, the participants of our study were comparable with regard to culture. However culture might be an additional determinant of perceived expertise, such as in cultures with high uncertainty avoidance, expertise has a greater weight, as compared to cultures with low uncertainty avoidance [26]. Therefore, differences in culture are supposed to have an impact on perceptions of expertise. Third, we analyzed perceived expertise in face-to-face group discussions. However, [27] has shown that computer-mediated groups produced more normative influence (via preference statements), while face-to-face groups produced informational influence (via arguments). Therefore, we assume differences in perceived expertise when group discussions are computer-mediated. Finally, we advocate more research to further explore the determinants of perceived expertise in groups.

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Factorization of large tournaments for the median linear order problem

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Abstract. Computing a median linear order on a set of linear orders on n elements, is an ordinary task for aggregating preferences. This problem is formalized by a tournament (complete directed graph) with n vertices, arcs corresponding to majority preferences. A median linear order has a minimum remoteness to this tournament. To build such an order is to make it transitive, realizing a minimum number of arc-reversal operations. This computation is made using a *Branch & Bound* algorithm which cannot be applied when n overpasses a few tens. In this text we try to decompose a large tournament ($n > 100$) into sub-tournaments and to assemble the orders on each one into a linear order on n elements. We show, making several simulations on random tournaments, weighted or unweighted, that this decomposition strategy is efficient.

Key words: Preferences, linear orders, tournament, median order

1 Problem

A group E of *experts* ($|E| = m$), ranking a set X of items ($|X| = n$), defines a linear order *profile* $\Pi = \{S_1, S_2, \ldots, S_m\}$. We try to establish a linear order π from this profile, being a median order for Π according to distance $\delta : S \times S \to \mathbb{N}$. It means that

$$\sum_{i=1,\ldots,m} \delta(S_i, \pi) \tag{1}$$

is minimum over the linear order set $\mathcal{S}$ on X [1].

Classically, δ is the symmetric difference distance between item pairs on X. Thus, to build a median order from profile Π a table T indexed on $X \times X$ is first computed. $T(x, y) = |\{S \in \Pi \text{ such that } x \prec_S y\}|$; evidently $T(x, y) + T(y, x) = m$. This table is associated to a tournament having arc (x, y) directed from x to y iff $T(x, y) > T(y, x)$. This arc can be weighted by $w(x, y) = T(x, y) - T(y, x)$ and $w(y, x) = 0$.

Often, in practical problems, preferences are not linear orders because of ties. In that case, preferences are weak orders. Nevertheless, the summarizing of a profile can be done the same way, defining a majority tournament.

A linear order is equivalent to a transitive tournament. Consequently, a set of arcs to reverse, denoted the *reversal arcs* set, is searched to make the computed tournament transitive. This set must have minimal weight to give a median order. It is the Kemeny (1959) problem, which is NP-hard (see [8] for a large survey). Using a *Branch & Bound* algorithm, a linear order π with minimum remoteness to the tournament is built. It is a median order for profile Π [6, 2]. Its remoteness W is the sum of weights of the reversal arcs, that are arcs directed from y to x, when x is before y in π:

$$W_{\Pi}(\pi) = \sum_{x \prec_{\pi} y} w(y, x). \tag{2}$$

For unweighted tournaments, it is the number of reversal arcs which must be minimized. It becomes the Slater problem [10], which is the same as before with weights all equal to 1. It is also NP-hard and the same algorithm is used to solve both problems.

In this article, we are interested with large problems ($100 \leq n < 1000$). They generally do not occur in preference aggregation, because experts cannot rank a so large number of items. But this type of instances exists when comparing functions defined over points on a triangulated surface. The points correspond to the items and the orders are defined according to models generating function values (as for simulation of car crashes). Some variables allow to compare these functions and a median function is searched either to characterize an average case or to define quantile of deformations. But we keep the preference aggregation scheme to develop our factorization method.

A transitive tournament corresponds to a single linear order, which is easily built ranking the internal half-degrees in increasing order. But if the tournament contains many circuits, the *Branch & Bound*procedure can be very long and fail because of computation time or memory to extend the tree. Each node corresponds to a beginning sections (prefix) of an linear order which can be extended to a median one. Despite many careful efforts [3, 4], as soon as n is larger than 20 elements, the tree can overpass 500 000 nodes. Then, heuristics are used to get an upper bound to the remoteness of an optimal linear order from the tournament, and also an approximate solution to the problem.

2 Classical heuristics

We only keep two of them, because the Borda's method (increasing order of the sum of item ranks in the profile) and the Smith & Payne method [11] (reversal of arcs involved in the largest number of 3-cycles) have been found without efficiency for the problem size we tackle.

2.1 The increasing order of internal half degrees

Vertex x is said to be *dominated* by vertex y when $T(y, x) > T(x, y)$ and the internal half degree of x is the number of vertices dominating x. It is very natural to put at the first place, in the searched linear order, vertex having the smallest degree and to continue according to this increasing order. This heuristic is the most efficient for unweighted tournaments. The degree sum is computed in $O(n^2)$ and the increasing order is in $O(n \log n)$.

2.2 The greedy heuristic

It uses the same principle as for the *Branch & Bound* procedure, except the tree of beginning sections is not developed. At each step the item promising the smallest remoteness is selected and the costs of the remaining items are updated. The column sums of the weight table are first computed

$$Sum(y) = \sum_{x \in X} w(x, y). \tag{3}$$

$Sum(x)$ is the contribution of x to the remoteness of an order beginning by x. At each step

– item x such that $Sum(x)$ is minimum is selected ;
– weights are updated : $Sum(y) \leftarrow Sum(y) - w(x, y)$.

This heuristic is clearly in $O(n^2)$; it is the best one for weighted tournaments.

There are many other stochastic optimization heuristics, for instances, Simulated Annealing (Metropolis), Variable neighborhood search [7] or the Noising methods [5]. We do not consider them in this study, because of parameters to adapt, computation time to manage, of computer codes only made by these authors. But any heuristic solution giving a linear order can be a starting point of optimization procedures. Again, we select only two of them that are deterministic.

2.3 Two local optimization procedures

Any heuristic establishes a linear order $O = (o_1, o_2, \ldots, o_n)$ on X. We apply two local optimization procedures. The first one is very classical : two consecutive items such that $w(o_{i+1}, o_i) > 0$ are searched. It is clear that transposing these elements will make the remoteness decrease, erasing a reversal arc. This procedure is iteratively applied until there is no such pair to apply.

The second one is only for weighted tournaments. For each element o_j, we seek for an item o_i placed before and dominated by o_j ; so we have $i \prec_\pi j$, $w(o_j, o_i) > 0$ and (o_j, o_i) is the shortest reversal arc from o_j. It is interesting to swap o_j and o_i if the items placed between o_i and o_j do not create reversal arcs with a larger weight. This is checked summing values

$$Q = \sum_{i>k>j} w(o_k, o_j) + \sum_{i>k>j-1} w(o_i, o_k). \tag{4}$$

The first sum corresponds to arcs ending in o_j and the second one to arcs starting from o_i which would became reversal arcs after swapping o_i and o_j. The last weight $w(o_i, o_{j-1})$ is not counted in the second sum because, if it is positive, it is enough to transpose o_{j-1} and o_i which takes the place of o_j.

So, if $w(o_j, o_i) > Q$ the interval $(o_i, o_{i+1}, \ldots, o_{j-1}, o_j)$ becomes either $(o_j, o_{i+1}, \ldots, o_i, o_{j-1})$, or $(o_j, o_{i+1}, \ldots, o_{j-1}, o_i)$ according $w(o_i, o_{j-1})$ is positive or not.

As far as I know, this latter optimization procedure is new and we have tested its efficiency. It is fast, since for each element, it suffices to go back to the last dominated item and to apply formula (1.4) within this interval ; its complexity is $O(n^2)$.

3 Factorization of a tournament

For median linear order problems of large size ($n \gg 100$), these heuristics are poorly efficient. We study the idea of a tournament decomposition in sub-tournaments, that is to separate the X items into clusters of close elements in a median linear order. It could be efficient to compute a linear order for each class and to concatenate them to make an order on X. We are going to test if this *composed* order is closer to the tournament than the classical heuristic ones when they are applied to X as a whole.

3.1 A balanced decomposition

The linear order given by the best heuristic ($BestH$, the one giving the smallest remoteness) infers a balanced decomposition. Given a number of clusters p, it suffices to built classes as intervals along this order. The n/p first ranked items are in the first class, the next n/p in the second, and so on. One get a partition in balanced clusters denoted P_B.

3.2 A partition based on a distance

Considering the W table of the arc weights, one can associate to each element x a bipartition : Let x_+, be the set of items which would be ranked before x because they dominate it, and x_-, those which would be placed after x because it dominates them.

$$x_+ = \{z \in X | w(z,x) > 0\} \text{ and } x_- = \{z \in X | w(x,z) > 0\}.$$

Using these bipartitions, on can define a dissimilarity index on X

$$D(x,y) = \Delta(x_+, y_+) + \Delta(x_-, y_-) \tag{5}$$

in which $\Delta(x_+, y_+)$ is the symmetric difference distance between sets x_+ and y_+ (resp. x_- and y_-).

Remark : D is not a distance, because $D(x,y) = 0$ if $w(x,y) = w(y,x) = 0$.

Proposition 1. *If T is a transitive tournament,*

- *Two consecutive elements in its median order have distance equal to 2 ;*
- *$D(x,y)$ is proportional to the rank difference between x and y in the median order ;*

– *D is a robinsonian distance.*

Proof. Let $x \prec y$ be two consecutive elements in the order corresponding to a transitive tournament. Classes x_+ and y_+ (resp. x_- and y_-) only differ by a single element, x (resp. y) and so $D(x, y) = 2$. In the same way, if x and y are separated by k items in the order, $D(x, y) = 2(k + 1)$. Thus, values increase along rows from the diagonal, and D is a distance (because there is no tie in preferences). This is the definition of a robinsonian distance.

Consequently, homogeneous classes according to D would gather close elements in a median linear order. The number of clusters, implying the average number of items per sub-tournament, will be defined by a simulation process described in section 4.

The partitionning algorithm is based on a criterion optimization. Given a partition of n items in p classes, denoted $P = \{P_1, \ldots, P_p\}$, it tends to minimize the sum M of the average distances of each element to the items belonging to its class.

$$M = \sum_{k=1}^{p} [\sum_{x \in P_k} \frac{1}{|P_k|} \sum_{y \in P_k} D(x, y)] \tag{6}$$

The resulting partition P_M is computed by an iterative procedure similar to k-means. One start from the atomic partition only made with singletons. At each iteration one element is assigned to the class for which its average distance is minimum. It stops when there is no more element to transfer.

3.3 Composition, Complexity and Efficiency

For each class from P_B or P_M, one evaluate

- its rank index value, equal to the average of its item ranks in the best heuristic order ;
- the sub-tournament corresponding to this class, with weights given in W ;
- a linear order minimizing, as much as possible, its remoteness to the sub tournament. For the following computations, I retain the first heuristic for unweighted problems and the second one for weighted tournaments.

Then, the linear orders corresponding to clusters are concatenated according their rank index values, making this way a *composed linear order*. The local optimization procedures are applied, making finally two linear orders, $Comp_B, Comp_M$ for the two decomposition methods.

The balanced decomposition algorithm is linear. The distance array computation in in $O(n^3)$, since for each item pair, the relative positions of n elements are compared. Partition P_M is established by an iterative algorithm, without to know its iteration number, as for k-means, which is well known for its efficiency. Then, classical heuristics are applied to each class followed by local optimization to the composed order which remain in $O(n^2)$.

Thus, the *Composed Linear Order* method is fast. For a tournament having 1000 nodes, a linear order in computed in 1"20 by P_B and 19"30 by P_M, using an ordinary desk computer.

4 Simulations and results

4.1 On random permutations profiles

The m permutations of order n selected at random make a profile [9] and the W matrix. The two classical heuristics give the $BestH$ linear order. Fixing the number of classes p makes on one side, the partitionning P_B and the composed linear order $Comp_B$ and on the other side, calculating distance D and applying the partitionning algorithm gives partition P_M and the $Comp_M$ linear order. For these three orders their remoteness to the tournament is measured.

Tests are made on 100 profiles with the same parameters. Each row in Table 1 gives the average remoteness. The three first columns are for unweighted tournaments and the three others for weighted ones.

n	m	p	$BestH$	$Comp_R$	$Comp_M$	$BestH$	$Comp_R$	$Comp_M$
100	10	3	805	788	**784**	755	731	**719**
100	20	3	832	814	**812**	1236	1203	**1187**
100	30	3	844	827	**825**	1569	1534	**1522**
200	30	4	3584	3520	**3514**	6825	6678	**6614**
200	50	5	3621	3542	**3536**	9047	8820	**8784**
200	100	6	3645	**3554**	3560	13129	**12762**	12782
500	100	5	23726	23476	**23456**	86600	85336	**85107**
500	100	10	23726	**23313**	23502	86600	**84670**	85635
500	100	15	23726	**23294**	23555	86600	**84636**	86078

Table 1 : Remoteness values of the orders given by heuristics on unweighted (left) and weighted (right) tournaments

The composed linear orders are much better than the best classical heuristic. They win at each trial, except for a few problems with $n = 100$. But these are average results and, for a specific problem, both decomposition methods must be applied. Two questions remain : which is the optimal number of class for factorization and how far are these figures from the optimum (a median linear order) ?

To answer the first one, we consider 100 orders on 300 items ($n = 300, m = 100$), for which we seek the optimal number of classes in the average. The two first columns correspond to unweighted tournament and the two others are again for weighted ones. Classical heuristics give remoteness values independent of p, respectively 8333 and 30240, always larger than those obtained factorizing the tournament.

p	$Comp_R$	$Comp_M$	$Comp_R$	$Comp_M$
4	8232	8222	29786	29644
5	8205	8197	29659	**29538**
6	8183	**8192**	29551	29561
⋮	⋮	⋮	⋮	⋮
10	8144	8225	29409	29832
11	8138	8226	**29397**	29856
12	**8137**	8243	29405	29913
13	8140	8245	29419	29938

Table 2 : Average remoteness values of the orders given by decomposition of unweighted (left) and weighted (right) tournaments, making the number of classes p vary.

Remoteness average values decrease when the class number increases, then they increase. It is why we don't go further. The minimum value is obtained with class number depending on the method. But the best decomposition is reached for 11 or 12 corresponding to around 30 elements per class.

4.2 Tournaments with bounded remoteness

Selecting independent permutations as before, generates tournaments far to be transitive and the computed orders have a large remoteness. The best linear order cannot be seen as a consensus order, because there is no meaningful consensus to these profiles. We are going to generate tournaments from a unique linear order, making transpositions between random items. Let t be the parameter counting the transposition number. There are two generating processes :

- Starting from the natural linear order, corresponding to a transitive unweighted tournament, one select at random t pairs. If $x < y$, $T(x,y) = 1$ and $T(y,x) = 0$. Transposing (x,y) will make $T(x,y) = 0$ and $T(y,x) = 1$. Doing so, we are sure there exists a linear order with a remoteness to the final tournament lower than or equal to t.
- The m permutations are built from the natural order transposing t random pairs in each one. The weighted tournament is then computed, according to the usual majority rule. But if t is small compared to n, the consensus and median order would be the natural order.

The first tests are for unweighted tournaments with $n = 300$ in which 2000, 3000, 4000 random transpositions are made, over the 34850 possible. So the median order must be very close to the natural order, for which the remoteness is calculated. The same algorithms as before are run with a factorization in 10 clusters :

n	t	p	$BestH$	$Comp_B$	$Comp_M$	$NatOrd$
300	2000	10	1965	1903	**1898**	1895
300	3000	10	2915	2796	**2786**	2779
300	4000	10	3841	3661	**3643**	3628

Table 3 : Average remoteness values for the $BestH$ heuristic, the two factorization methods and the natural order expected to be a median one, on unweighted tournaments obtained after t random transpositions.

These are again average values over 100 problems. The given bound, equal to t is largely improved by composed linear orders. And partition P_M provides values very close to those of the natural order suspected to be optimal.

The second test is made with permutations on which 100 transpositions have been made before to calculate the weighted tournament. Factorizations are always made with 10 classes.

n	m	t	p	$BestH$	$Comp_B$	$Comp_M$	$NatOrd$
300	30	100	10	2065	1721	**1434**	1555
300	50	100	10	800	677	**558**	544
300	100	100	10	56	51	**49**	46

Table 4 : Average remoteness values for the same linear orders as in Table 3, on weighted tournaments obtained after t random transpositions on m natural orders.

The larger is the number of permutations (m), the lower is the remoteness because the corresponding tournament becomes transitive. The second decomposition method proves its efficiency for problems with a strong consensus.

5 Conclusion

The factorization strategy is always the winner. And so, it is better to concatenate small orders optimized from sub-tournaments than to compute an optimized linear order from the whole tournament. More, for tournaments close to be transitive, the P_M decomposition gives linear orders close to the median one.

So, for a large specific tournament coming from real data, I will first compute an optimal number of classes with the balanced partitionning, which is very fast, since there are no distance array to measure. And around this value, I will test partitionning algorithms. A last trial with a 1000 vertices tournament provides, with the balanced decomposition in 15 clusters, the smallest remoteness value.

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Portfolio optimization and preferences

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Abstract

In this paper we address two issues considered as weaknesses of the Mean-Variance, respectively Mean-Risk, portfolio selection models. The first one is related to the amount of significant information contained in the return distributions, but ignored during the decision process, and second is the implicit assumption of neutrality at risk of the individual investor. We work with the forecasted empirical return distribution function; thus the higher moments of the return distributions and implicitely the information contained in them are not neglected. We propose a portfolio selection model incorporating the individual preferences in the objective related to the portfolio return. We evaluate the differences and the similarities between the two efficient frontiers corresponding to the proposed model and the classical Mean-Variance.

Keywords: Quantile-based risk measures, Portfolio optimization, Mean-Risk model, Utility functions.

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1. Introduction

A crucial question in financial management is how to combine risky assets into a portfolio such that the investment decision taken at the present moment has the most rewarding consequences at the end of a given time horizon T. Starting with Markowitz' seminal work [2], the most used approach for solving the portfolio selection problem in practice relies on the *Mean-Risk* models. In this framework, the decisions are based on the comparison of two numerical values characterizing the portfolio return distributions: the expected value and the value of a particular risk

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measure. The fact that during the optimization process only these two statistics are taken into consideration have attracted some criticism from two viewpoints:

- the first one is related to the amount of significant information contained in the distribution which is ignored and therefore lost for the decision process,
- the second is driven by the very practice of risk which shows that individual investors can differ in their attitudes toward risk, in their preferences and hence in what they consider a suitable *Mean-Risk trade-off*.

In order to correct the first shortcoming, many researchers have argued that the higher moments of the portfolio return distribution cannot be neglected. One way to achieve this is by droping the usual simplifying assumptions about the returns distributions (like the hypothesis of being gaussian or spherical or eliptical) and working with the empirical distributions, more precisely with the forecasted ones which depend on their higher moments. Other authors consider that the higher moments should be added to the *Mean-Risk* model as objective functions. Consequently, in some recent studies, the concept of *Mean-Variance trade-off* has been extended to include the skewness of return in portfolio selection, or the kurtosis.

The second reason of skepticism regarding the basic *Mean-Risk* models is driven by the implicit disregard of the individual investors preferences. The investors' preferences are usually described by increasing, smooth and concave utility functions. In this paper we consider the exponential utility defined as

$$U(w) = \frac{1}{\xi}\left(1 - e^{-\xi \cdot w}\right), \ w \in R, \tag{1}$$

where the parameter $\xi = A_a(w), \forall w$, where $A_a(w) = -U''(w)/U'(w), \forall w$, is the coefficient of absolute risk aversion.

In this paper, we address both these issues by considering portfolio selection models in the *Mean-Risk* framework, but allowing the consideration of individual preferences by using the decision-maker's specific utility/disutility function. And moreover, we work with the forecasted empirical return distribution function which allows the dependence of the return distribution on its higher moments. Thus, the information contained in the distribution is fully taken into consideration.

2. Utility-based portfolio selection models

Let n be the number of securities available for the portfolio. The key random inputs in the portfolio management problem are the asset prices at the end of the planning horizon denoted by $p(\omega) = (p_1(\omega), ..., p_n(\omega))$, $\omega \in \Omega$ or simply by $\boldsymbol{p}$ (we use bold symbols for vectors). The set Ω represents the set of future states of knowledge and has the mathematical structure of a probability space with a probability measure P for comparing the likelihood of future states ω. Let $l(\boldsymbol{x}, \boldsymbol{p})$ be the loss associated with the decision vector $\boldsymbol{x} \in X \subset R^n$ and the random vector $\boldsymbol{p}$, where $\boldsymbol{x}$ is interpreted as a portfolio and X is the set of available portfolios subject to various constraints. The loss equals to the difference between the initial wealth W_0 and the final random wealth, $l(\boldsymbol{x}, \boldsymbol{p}) = W_0 - W$, where $W = \boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{p}$. Positive outcomes of loss function are disliked, while negative outcomes are welcome because they represent gains. For each $\boldsymbol{x} \in X$, the loss $l(\boldsymbol{x}, \boldsymbol{p})$ is a random variable having a distribution in R induced by that of $\boldsymbol{p}$. Throughout this paper, the loss function can have a more general form if it is continuous in $\boldsymbol{x}$, measurable in $\boldsymbol{p}$ and $E(|l(\boldsymbol{x}, \boldsymbol{p})|) < \infty\ \forall \boldsymbol{x} \in X$. The underlying probability distribution of $\boldsymbol{p}$ in R^n is assumed to have the probability density function (pdf) denoted by $g(\boldsymbol{p})$, $\boldsymbol{p} \in R^n$.

Variance was the first risk measure used in portfolio optimization, Markovitz [2]. More recently, regulations for finance businesses formulate some of the risk management requirements in terms of percentiles of loss distributions. The most commonly used is the *Value at Risk* (*VaR*). Given z a level of losses, the cumulative distribution function (cdf) of $l(\boldsymbol{x}, \boldsymbol{p})$ is defined by $G_{l(\boldsymbol{x},\boldsymbol{p})}(z) = P(\{\boldsymbol{p} \,|l(\boldsymbol{x}, \boldsymbol{p}) \le z\}) = \int_{l(\boldsymbol{x},\boldsymbol{p}) \le z} g(\boldsymbol{p})\, d\boldsymbol{p}$ and is assumed continuous with respect to z. Let $G^{\leftarrow}_{l(\boldsymbol{x},\boldsymbol{p})} : (0,1) \to R$ be the $\alpha-$quantile function, given by $G^{\leftarrow}_{l(\boldsymbol{x},\boldsymbol{p})}(\alpha) = \min\limits_{G_{l(\boldsymbol{x},\boldsymbol{p})}(z) \ge \alpha} z$. Within risk management, it is called the *Value at Risk* of the loss $l(\boldsymbol{x}, \boldsymbol{p})$ at a probability level of $\alpha \in (0,1)$ and denoted by $VaR_\alpha(l(\boldsymbol{x}, \boldsymbol{p}))$ or $z_\alpha(\boldsymbol{x})$. *VaR* can be efficiently estimated and managed when underlying risk factors are normally distributed. However, for non-normal distributions, *VaR* may have undesirable properties (see Artzner et al. [1]) such as the lack of sub-additivity. Also, *VaR* is difficult to control/optimize for discrete distributions, when it is calculated using scenarios. In this case, *VaR* is non-convex and non-smooth as a function of positions, and has multiple local extrema. To alleviate these problems, Artzner et al. [1] introduced the concept of coherent risk measure and proposed the *Conditional Value at Risk* (*CVaR*). The *CVaR* of the loss $l(\boldsymbol{x}, \boldsymbol{p})$ at probability level $\alpha \in (0,1)$ proved to be coherent. The dedicated notation which associates any portfolio $\boldsymbol{x} \in X$ to its corresponding $CVaR_\alpha$ is $\phi_\alpha : X \to R$ given by

$$\phi_\alpha(\boldsymbol{x}) = \frac{1}{1-\alpha} \int_{l(\boldsymbol{x},\boldsymbol{p}) \ge z_\alpha(\boldsymbol{x})} l(\boldsymbol{x}, \boldsymbol{p})\, g(\boldsymbol{p})\, d\boldsymbol{p}. \tag{2}$$

The *CVaR* continues to be intensively studied and applied in different contexts. Due to its good properties both from theoretical and computational point of view, the

Mean-Risk models studied in this paper are based on the *CVaR* risk measure.

We consider the single-period portfolio problem which involves portfolio decisions in response to new information on market future prices (returns) of the risky assets. The decision maker starts (at $t = 0$) with an initial portfolio $\boldsymbol{x_0} \in R^n$ having full knowledge of the current asset prices $\boldsymbol{p_0}$. We consider the vector of asset logarithmic rates of return $\boldsymbol{r} = (r_1, ..., r_n)^T$. The action taken on asset i at time $t = 0$ is denoted by u_i and represents the amount of the i^{th} purchased/sold asset. The investor can either hold the asset i ($u_i = 0$), buy more ($u_i > 0$), or sell off a part of asset i ($u_i < 0$). The decision vector is $\boldsymbol{u} \in R^n$ and the adjusted portfolio is $\boldsymbol{x} = \boldsymbol{x}_0 + \boldsymbol{u}$. We assume that no short selling is allowed, i.e. $\boldsymbol{x} \geq 0$. Buying and selling causes transaction costs which we assume to be proportional to the amount of asset traded. In our model, $100c$ represents the transaction costs expressed as a percentage associated with buying/selling one unit of asset i. The budget constraint $\boldsymbol{x}^T \boldsymbol{p_0} + \sum_{i=1}^{n} p_{0,i} |u_i| \, c = W_0$ represents the assumption that there is no exogenous intervention in the amount of money involved in transactions during the time period. The basic *Expected wealth/return-CVaR (E-CVaR)* model with transaction costs is:

$$\min_{\boldsymbol{x} \in X} \left(-E\left(W\left(\boldsymbol{x}, \boldsymbol{p}\right)\right), CVaR_\alpha\left(l\left(\boldsymbol{x}, \boldsymbol{p}\right)\right)\right) \tag{3}$$

$$X = \left\{ \boldsymbol{x} \in R^n \,\middle|\, \boldsymbol{x}^T \boldsymbol{p}_0 + \sum_{i=1}^{n} p_{0,i} |u_i| \, c = W_0, \ 0 \leq x_i \leq \frac{W_0}{p_{0,i}}, \ i = \overline{1, n} \right\} \tag{4}$$

We note that the model (3)-(4) is the same for all investors, whatever their risk profile. A more realistic approach is to consider that the decision maker is characterized by an increasing convex disutility function D. We mention that we use the notations: D for the investor's increasing convex disutility function when we refer to losses, and U for the corresponding increasing concave utility function of the same investor when we refer to wealth/returns, where $U(w) = -D(-w), \forall w \in R$. Introducing the utility/disutility function in the portfolio model will allow the selection of not only profitable, but also suitable portfolios. The models to be studied in this paper are designed to meet this requirement. Following this path, we note that the influence of the investor's preferences can be incorporated in the first or in the second objective function of the basic model (3)-(4).

2.1. Incorporating the investor's preferences in the mean

Firstly, for a given probability level $\alpha \in (0, 1)$, we consider the class of models

$$\min_{\boldsymbol{x} \in X} \left(-E\left(U\left(W\left(\boldsymbol{x}, \boldsymbol{p}\right)\right)\right), CVaR_\alpha\left(l\left(\boldsymbol{x}, \boldsymbol{p}\right)\right)\right) \tag{5}$$

incorporating the preferences in the first objective function of (3)-(4). These models are maximizing the expected utility of the portfolio terminal wealth/return and simoultaneously minimizing the *CVaR* of the portfolio loss distribution. The model (5) will be referred to as the *Expected Utility-CVaR (EU-CVaR)* portfolio model.

2.2. Comparison of the E-Var and EU-CVaR efficient frontiers for the CARA class of utility functions

In order to quantify these differences we have calculated the differences in composition and the relative variations of the weights of the *E-Var* efficient portfolios in relation to the *EU-CVaR* efficient portfolios. We have followed the procedure described in Phillips [3], the results are presented in Table 1. The computational results corresponds to a CARA utility (1) with $\xi = 2.5$.

- The sub-table *Common assets*. The diagonal terms represent the average number of assets in the respective efficient frontier. The off-diagonal terms represent the average number of assets in common for efficient portfolios of both corresponding models. For example, the pair of efficient frontiers $EU - CVaR$ / $E - Var$ has an average of 7.26 assets in common.

- The sub-table *Portfolio overlap index*. Each off-diagonal term represents the average percentage of common assets for the corresponding models. For example, the value of 76.42% means that on average, 76.42% of asset contained in an $E - Var$ efficient portfolio are also contained in $EU - CVaR$. This does not mean that the portfolios are almost identical because the weights within portfolios could vary markedly - this has major investment implications. When two portfolios have the same composition the overlap is 100% (the diagonal terms).

- The sub-table *Portfolio weight index*. Each off-diagonal term represents the sum of the minimum weights corresponding to each common asset for the corresponding models. This index measures the importance of the respective asset in the portfolio, therefore it is a measure of how similar are the two portfolios due to the weights of the assets. An off-diagonal value of this index close to 100% would mean that the weights of all common assets are almost the same. For example, the value of 39.96% corresponding to the pair of efficient frontiers$E-Var$ / $EU-CVaR$ for which the *Portfolio overlap index* is 76.42% indicates that on the average the variation in weight goes from simple to double.

- The sub-table *Portfolio similarity index*. Each off-diagonal term is calculated as the product of the *Portfolio overlap index* and the *Portfolio weight index* for

Indices	Model	$E - Var$	$EU - CVaR$
Common	$E - Var$	100	
assets	$EU - CVaR$	7.26	100
Portfolio	$E - Var$	100	
overlap	$EU - CVaR$	76.42	100
Portfolio	$E - Var$	100	
weight	$EU - CVaR$	39.96	100
Portfolio	$E - Var$	100	
similarity	$EU - CVaR$	30.53	100

Table 1: Analysis of asset allocation similarity.

each model. This index gives the proportion of common assets to both models with similar weights. For example, if we consider the same pair of efficient frontiers as before $E - Var$ / $EU - CVaR$, the value of 30.53% represents the percentage of common assets having similar weights in portfolios belonging to these two efficient frontiers.

We conclude from this analysis that the model $EU - CVaR$ shows a low similarity of 30.53% with the $E - Var$ model and therefore the consideration of the preferences results in a different investment. Subsequent work will show the advantages of using the $EU - CVaR$ model instead of the classic $E - Var$.

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PART X

Real Case Studies

Be Yourself? – Authenticity in Negotiations

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Abstract. Since negotiation behavior plays a crucial role in predetermining negotiation processes and outcomes, research is very interested in an individual's personality, which has been proven to impact negotiation behavior. Moreover, it has been revealed that personality influences the application of a specific negotiation style (e.g., dominating, integrating, etc.). Consequently, all negotiators have a typical negotiation style that is in accordance with their personalities. If a typical style is applied, we define this as authentic negotiation behavior; if not, non-authentic negotiation behavior is exhibited. Interestingly, no study has to date dealt with the concept of authenticity in negotiations and analyzed its impact on negotiation outcome. Therefore, this paper examines authenticity in two different negotiation settings: in a long-term business relationship and in a one-shot negotiation. Our findings reveal that negotiating authentically yields better negotiation outcomes in a long-term relationship setting, whereas non-authentic behavior is more profitable in a one-shot negotiation.

Keywords: personality, negotiation style, authenticity, negotiation outcome

1 Introduction

Negotiators' behavior during a negotiation encounter is of interest across all areas of negotiation research (e.g., organization behavior and industrial relations) [1]. The objective is to predetermine the negotiation process and negotiation outcome [e.g., 1]. However, to be able to understand negotiation processes and outcomes, many studies assume that individual differences, such as culture, gender, or personality [2], play an important role in influencing negotiation behavior [3]. In this context, the personal characteristics of negotiators have a long research history [2, 4].

In the related literature, personal characteristics – mostly captured by means of five different personality traits, the Big Five Inventory [5] – and their impact on negotiation behavior are analyzed from different points of view. For example, some scholars examine the influence of personality on the level of first offers, offer differences, and aspiration prices [3] or on the preference for single negotiation issues [6]. Other studies concentrate on the relationship between personality traits and the applied negotiation style [e.g., 7, 8, 9], which is defined as learned patterns of behavior that can be adjusted and developed, but which the individual's personality simultaneously influences substantially [2]. Based on this understanding, scholars have revealed that certain personality traits are positively correlated with specific negotiation styles [e.g., 7, 8, 9]. Thus, all negotiators have a characteristic negotiation style in accordance with their personalities. If a negotiator applies this typical style, we define this as authentic negotiation behavior; if not, non-authentic negotiation behavior is exhibited. Interestingly, although authenticity has been examined in various research areas, such as psychology [e.g., 10], relationship marketing [e.g., 11], and leadership research [e.g., 12], only one study on negotiation research has dealt with the authenticity construct [13]. However, this study is limited to the role of authenticity in process fairness behavior. Thus, there is no study that analyzes the impact of authenticity on negotiation performance.

Consequently, the primary aim of our paper is to examine, the influence of authenticity on negotiation outcome. In order to gather comprehensive findings, we first analyze the impact of authenticity on negotiation performance in a long-term business relationship, during which a single negotiation party meets his or her negotiation partner several times and thus know her or him well. Second, we examine this impact on a one-shot negotiation, during which negotiators encounter their respective negotiation partner only once.

In the following, we develop the theoretical background and derive our research questions. Subsequently, we describe a negotiation experiment, as well as our data analysis and the results. We conclude with a discussion of our results' implications for both research and practice.

2 Theoretical Background

As mentioned above, individual differences, such as personality, influence and thus determine preferences regarding negotiation styles [e.g., 2]. Mostly, five different negotiation styles [e.g., 14], structured along the dimensions concern about own outcomes and concern about the other party's outcomes, are differentiated [15]. To illustrate, negotiators who focus on their outcomes and neglect the interests of their negotiation partner, can be described as applying a dominant negotiation style [e.g., 16]. In contrast, integrative negotiators try to obtain the best possible outcome for each party [e.g., 17]. The compromising negotiation style, in which negotiators show a moderate concern for the own and the other party's interest, is a combination of these two styles [e.g., 18]. The obliging negotiation style describes parties who neglect their own needs, while negotiators applying the avoiding style show little concern about both outcome dimensions [e.g., 16].

So far, studies have found that negotiators' specific personalities, which can be classified into five dimensions [19], impact their individual preferences for one of these five styles [7, 9]. These five factors – known as the Big Five – subsume a variety of specific personality traits [3].Thus, the factor (1) extraversion reflects a personality who is assertive, talkative, outgoing, active, and has a positive relationship with the dominant and integrating style; (2) agreeableness is associated with a generous, appreciative, and forgiving person who tends to apply the integrating, the compromising, avoiding or obliging style; (3) conscientiousness describes a reliable, responsible, and organized personality, thus predicting the use of the integrating style; (4) neuroticism explains a personality that is often worried, anxious, and unstable, who thus generally uses the avoiding negotiation style or the obliging style; (5) openness reflects the personality traits insightful, curious, and imaginative, which have a positive relationship with the integrating style [7, 19]. However, in this context, it has to be indicated that the obliging style is barely used in negotiations [e.g., 20]. Furthermore, since these specific negotiation styles depend on an individual's personality, they can be characterized as natural styles for the respective personality and, thus, as authentic negotiation behavior. This is due to authenticity being defined as showing one's true self and acting in accordance with one's preferences [21]. However, it is also possible that negotiators do not apply the negotiation style that is characteristic of their personality, which would mean that they exhibit non-authentic negotiation behavior.

To the best of our knowledge, no study has as yet analyzed the impact of authenticity on negotiation outcome – in spite of its high relevance, as mentioned above. In this context, it is conceivable that negotiators generally apply the most appropriate style for the specific negotiation situation, regardless of their attributed negotiation style, which may be non-authentic. By adapting their style to the situation they could optimize their individual negotiation outcome. On the other hand, it may be possible that being authentic in negotiations yields a better individual negotiation outcome, because the negotiation partner is perceived as more reliable. Furthermore, as in long-term business relationships, where trust plays an essential role and authenticity thus might be more valued, it is relevant to examine authenticity in negotiations in two different negotiation situations: once in a long-term business relationship and once in a one-shot negotiation. Therefore, we derive the following two research questions:

RQ_1: Which negotiation behavior – authentic vs non-authentic – yields a better individual negotiation outcome in a long-term business relationship?

RQ_2: Which negotiation behavior – authentic vs non-authentic – yields a better individual negotiation outcome in a one-shot negotiation?

3 Empirical Study

3.1 Methodology

To examine authenticity in negotiations and its impact on an individual negotiation outcome, we conducted a negotiation experiment in one of our negotiation classes. Participation was voluntary, although the achieved negotiation outcome was part of the grading system. In total, our experiment relied on 90 negotiations in a long-term business relationship setting and on 92 negotiations in a one-shot negotiation setting. In the long-term business relationship scenario, the students were either assigned the role of the buying or selling firm and were provided with role-specific information. The subjects had to obtain certain agreements in respect of their negotiations, which would take place in the public sector. Thereby, the negotiators were informed that they encounter his or her assigned negotiation partner in several consecutive negotiations without knowing how many negotiation rounds would take place. By means of this, we had simulated a long-term relationship and ended the experiment unexpectedly for the negotiators. Each of the four negotiations lasted 15 minutes. In the one-shot negotiation scenario, the students had to come to an agreement on a salary negotiation in the private sector. Role-specific information was distributed to both roles – the company and the employee. The negotiation time was also restricted to 15 minutes. In both scenarios there was also an option of not coming to an agreement.

The negotiators had to fill in two questionnaires. First, they had to indicate how they assessed their personality for which we used the German version of John et al.'s [22] five-point Likert scale (44 items) [23]. Second, the negotiators had to indicate their negotiation style preference on the German version of Rahim's [14] five-point Likert scale (28 items) [24]. In order to avoid biases, the personality scale had to be filled in one day before the negotiations took place; the negotiation style scale was answered right before the negotiations. These two self-assessments are well established and therefore allowed us to analyze whether the negotiators had exhibited authentic negotiation behavior (the negotiation style matches the personality), or non-authentic negotiation behavior (the negotiation style differs from the specific personality).

3.2 Results

To answer our research questions, we categorized the negotiation parties' behavior as either authentic or non-authentic according to their respective personality and applied style. Therefore, we first analyzed – by calculating the respective mean scores –, the personality of the subjects and, secondly, their negotiation style, in order to examine whether the personality conformed to the style and, thus, whether the subject is authentic or non-authentic [7]. In total, 30 subjects exhibited authentic negotiation behavior in the long-term business relationship, whereas 60 negotiators behaved non-authentically. Regarding the achieved individual negotiation outcomes, the results reveal that being authentic yields a significant better negotiation outcome in long-term business relationships than being non-authentic. However, the one-shot negotiation scenario, in which 29 subjects exhibited authentic behavior and 63 negotiators non-authentic behavior, shows a different picture. In this case, the non-authentic negotiation parties obtained a significantly better individual negotiation outcome ($p<.05$) than the authentic negotiators did. Table 1 shows the standardized individual negotiation outcomes across the two categories:

Table 1: Individual Negotiation Outcomes (students' independent samples t-test)

Student's t-test for independent samples					
Negotiation Scenario	Authenticity	N	Standardized Mean Negotiation Outcome	Std. Deviation	Sig. (2-tailed)
Negotiation Outcome Long-term business relationship	authentic	30	**.0601847**	.28020794	*
	non-authentic	60	-.0422192	.28216461	
Negotiation Outcome One-shot negotiation	authentic	29	-.1263112	.20954504	***
	non-authentic	63	**.0590159**	.30541531	
*** p<.001; ** p<.05; *p<.10					

4 Discussion

The primary aim of our study was to comprehensively analyze the impact of authentic behavior in negotiations. Against the background, that authentic behavior in general is described as reflecting one's true self and acting in accordance with one's preferences [21], we were interested in analyzing its impact on long-term business relationships and on one-shot negotiations. Our results reveal that being authentic can yield better negotiation outcomes, but that this depends on the character of a negotiation. It is better to negotiate authentically if a negotiation takes place in the context of a long-term business relationship. However, if negotiation partners encounter each other only once – in a one-shot negotiation – being non-authentic achieves better negotiation outcomes.

As authenticity has not been analyzed in negotiation research before, our results seem interesting for practitioners and further research. First, they show that in long-term relationships, in which trust plays a crucial role and negotiation partners know that their behavior could have consequences for the future relationship with their counterparty, negotiators should be authentic and not pretend to be someone else. This behavior will allow them to optimize their individual outcomes. Against this background, organizations should provide trainings for practitioners to learn about the negotiation style that best matches their personality. However, for one-shot negotiations, our results suggest that practitioners should be trained to apply the most appropriate style for the respective situation rather than being authentic. This first study demonstrates that researchers should definitely pursue the analysis of the authenticity construct. In addition, concrete indications for future research can be derived from our study's limitations and shortcomings. Our study has only conceptualized authenticity from a consistency perspective – the personality matching negotiation style. However, it is possible that the counterparty's perception of whether a negotiator is authentic or non-authentic is more crucial than actual authenticity. This would mean that if a negotiation party is non-authentic, this could be perceived as authentic and, thus, obtain better negotiation outcomes. We also did not examine – owing to small groups – whether a party's individual negotiation style itself has an influence on the negotiation outcome. Thus, an authentic behavior may always yield the most profitable outcome for negotiators with an integrating negotiation style – the most efficient one [e.g., 25]. Therefore, further research is necessary to analyze authenticity in negotiations with regard to the applied negotiation style.

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Study on Temporal Change of Social Context: In the case of Bicycle Riding Issue in Japan

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Abstract. For decision making in a community, a set of alternatives needs to be identified. The set of alternatives should be consistent with recognition in a community (Social context). In this study, we define "social context" as typical wording in community. Such wording appears in newspaper articles. We focus on the issue of bicycle riding in Japan and clarify the change of social context by using newspaper article. We show that wording in newspaper articles on bicycle riding in Japan has been changed during the past decade.

Keywords: Social context, Newspaper articles, Text mining, Wording

1 Introduction

In the science of decision making, the effect of wording on people's behaviors is regarded as a framing effect. Levin et al. [1] presented some experimental examples of risky choice framing where the wording of the outcome categories could affect respondents' answers. Wording affects not only individual decisions, but also group decisions. Liberman et al. [2] have reported on the effects of the "name of the game" in a prisoner's dilemma experiment. One half of the subjects described "the Wall Street Game" while the other half described "the Community Game". Though the payoff structures of both games were identical, the names of the games affected subjects' choices. More than half of the subjects cooperated when playing the Community Game, whereas only one third of the subjects cooperated in the Wall Street Game. Ellingsen et al. [3] have conducted similar experiments in which the names of the games were "the Stock Market Game" and "the Community Game". Although they reported similar results, they also showed that the social framing effect vanished when the game was played sequentially. Based on their results, Ellingsen et al. [3] concluded that social frames were imbibed in people's beliefs rather than in their preferences.

Wordings are also important in participatory planning process in a community. Participants' ideas are summarized and some of them are adopted as alternatives. Their ideas are described through the use of language. If participant's idea is described through the wordings which are broadly shared with other people, they can understand the idea easily. If the wording used for the idea is different from the shared wordings in a community, other people may not understand the meaning of the idea. Our previous study [4] showed that the ideas whose wordings have similarity with the wordings in a community tended to be adopted as alternatives. In this study, newspaper articles were used as the source of wordings in a community. However, wordings shared in a community can be changed with time. We focus on the issue of bicycle riding in Japan and clarify the change of wordings in a community by using newspaper articles. The objectives of this study are to show the relationship between wordings and policy decisions on bicycle issue and to show the change of social context.

2 The outline of the problems

2.1 Our approach

Fig. 1 illustrates our basic model of community governance. The set of alternatives is constrained by the social context (I). A community chooses an alternative from set (II) and subsequently implements it (III). The result of the implementation, in turn, affects the social context (IV). In this study, we focused on the framework wherein the set of alternatives was recognized by community members (I). In the actual community decision-making process, the set was not exogenously given. In other words, the set of alternatives was determined through the recognition of community members. When this recognition was altered, the set of alternatives could correspondingly be reorganized, and the final alternative selected could be changed. However, as alternatives were described through the use of language, recognition of community members was apparent in the specific wording used for describing alternatives. In other words, the wording used in a community constrains the way in which alternatives are described. In this study, we define "social context" as the wording used within a community. When social context (wording in a community) is altered, alternatives discussed in a community can also be changed.

However, social context cannot be observed directly. In the field of political science, it has been discussed that newspaper articles reflect community's recognition on issues [5] [6]. Based on their discussions, we assume that social context (typical wording in a community) appears in wordings of newspaper articles.

As shown in Fig.1, social context can be affected by the result of implementation of the past alternative (IV) and concerns in a community. If implementation resolved the problem, priority of the problem for a community may fall. On the other hand, if community members recognize a newly emerged problem, social context can be altered. In this study, temporal change of social context is observed through wording in media articles. By comparing the change with the decisions in a community, appropriateness of the model in Fig.1 is examined.

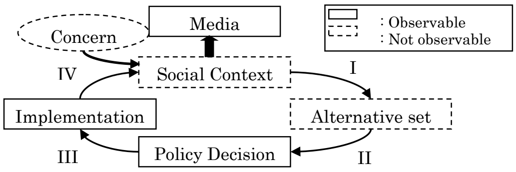


Fig. 1. Our basic model for community governance

2.2 Situation about the bicycle riding in Japan

In Japan, some people use a bicycle as "vehicle," while the other people regard a bicycle as "substitute for walking." Japanese society has not reached a consensus on the role of a bicycle in transportation. The situation is causing some problems. As far as a bicycle is regarded as a vehicle, a bicycle rider must keep to the left on roadway like a car driver. However, some people ride a bicycle on a sidewalk. As a result, pedestrians carry the risk of getting into a bicycle accident on sidewalk. Additionally, the environment for bicycle riding, such as the bicycle lane, has not been developed well. Another problem is illegally parking of a bicycle. At train stations, public space is often occupied by bicycles. Since some people consider a bicycle as substitute for walking, they do not hesitate to park their bicycle illegally.

3 Methodology

3.1 Data collection

In 2.1, social context was defined as wordings in newspaper articles. In order to detect the social context of bicycle riding in traffic policy, it is necessary to collect newspaper articles on bicycle riding in traffic policy. In this study, we used the database of newspaper articles in Japan named "Yomidas" [7] for collecting the articles. This database is provided by *Yomiuri journal* in Japan. First, the articles including the two keywords "traffic" and "bicycle" were collected from newspaper articles in the year 2002, 2006, 2007 and 2012. In order to specify the articles on bicycle, only the articles whose title include "bicycle" were chosen for analysis.

3.2 Co-occurrence analysis

For analyzing temporal change of social context reflected in wording in newspaper articles, two types of analysis were conducted. First we identified the related words with the keyword "bicycle", and then drew the network diagram of the co-occurring words. Both analytical methods are based on the concept of "co-occurrence" of words. Co-occurrence of words is quantified by *Jaccard* coefficient [8]. *Jaccard* coefficient (*Jaccard* index) is used for comparing the similarity and the discrepancy of usage of words in text data. *Jaccard* coefficient of words A and B is defined as follows,

$J(A, B)$ = (The number of sentences containing A AND B) / (The number of sentences containing A OR B) (1)

Jaccard coefficient shows how often these words are used in newspaper articles simultaneously. If the *Jaccard* coefficient of words A and B is high, these two words tend to be used frequently in the same sentence on newspaper article. Let X be a word. When J ("bicycle", X) is high, X is called the related word of "bicycle." In order to analyze the change of the social context, we focused on the changes of related words of "bicycle." As an example, we assume that J ("bicycle", X) was high in early period, then J ("bicycle", Y) has become high later. In such case, X represented the issue on bicycle in early period, and then the issue was shifted from X to Y.

The relationship of co-occurring words is also shown as network diagram. First, the sentences which include the word 'bicycle" are chosen for network diagram. Then two words with high *Jaccard* coefficient are connected with a link. In the following analysis, the top sixty pairs with the highest *Jaccard* coefficient are chosen for drawing links. In this study, related words and network diagrams of co-occurring words are detected by using KH Coder. KH Coder is the software for content analysis and text mining [9]. Unit for analysis is one word in Japanese, but some Japanese words are shown as two or more English words after translation.

3.3 Comparative observation

For comparing social context (wording in newspaper articles) on bicycle with actual policy discussion, we focused on three agencies. The first is Ministry of Land, Infrastructure, Transport and Tourism (MLITT), the second is National Police Agency (NPA) and the third is Bicycle Usage Promotion Study Group (BUPSG). MLITT and NPA are the agencies of central government of Japan, and BUPSG is NGO. In order to describe societal changes of bicycle riding, we focus on the activities of these agents and marshal different elements of them.

4 Results

4.1 The change of related words

Table 1. shows the number of collected articles and the number of sentences in each article. In 2002, for example, the number of articles including the words "bicycle" and "traffic" is 579, of which 106 articles include "bicycle" in their titles. These 106 articles consist of 1475 sentences, of which 483 sentences include the word "bicycle". Table 2. shows the related words with "bicycle" in newspaper articles and their *Jaccard* coefficients with "bicycle" in 2002, 2006, 2007 and 2012. The top 40 words with the highest *Jaccard* coefficient with "bicycle" are shown. The three words "traffic", "accident" and "safety" were common in each year. It suggests that there were many sentences about "bicycle accident" and "bicycle traffic safety". On the other hand, there are some keywords which independently appeared in each year. "Bicycle-parking area", "keeping" and "survey" appeared only in 2002. These words suggest "illegally-parked bicycle" problem. The word "illegally-parked" showed the second highest *Jaccard* coefficient with "bicycle" in 2002. However, its ranking had dropped to the 35th highest in 2007 and finally it did not appear in 2012. This result suggests that "illegally-parked" were often used with "bicycle" on the newspaper articles from 2002 to 2007, while the word became not to be used with "bicycle" in 2012. On the other hand, the word "roadway" had changed to be used with "bicycle" on the newspaper articles from 2007 to 2012 because the order of "roadway" has risen from being unranked in 2002 and 2006 to18th in 2007. Moreover it rose to 15th in 2012. These results show that the changes of social context on bicycle can be observed by the change of related words with "bicycle."

Table 1. The total number of articles and sentences analyzed in this paper.

	2002	2006	2007	2012
Articles including “traffic” and “bicycle”	579	672	647	842
-Articles whose title including “bicycle”	106	176	136	277
-Total sentences	1475	2305	2098	3854
-Total sentences including “bicycle”	483	846	830	1595

Table 2. Related words with “bicycle” in 2002, 2006, 2007 and 2012.

YEAR	2002		2006		2007		2012	
N	**Word**	***Jaccard***	**Word**	***Jaccard***	**Word**	***Jaccard***	**Word**	***Jaccard***
1	traffic	0.199	traffic	0.238	accident	0.206	traffic	0.194
2	***illegally-parked***	0.172	accident	0.215	traffic	0.196	accident	0.193
3	accident	0.135	riding	0.166	safety	0.144	safety	0.125
4	safety	0.112	safety	0.134	ride	0.094	riding	0.118
5	ride	0.100	prefectural police	0.106	riding	0.094	use	0.112
6	use	0.085	ride	0.100	sidewalk	0.085	ride	0.095
7	walking	0.065	***illegally-parked***	0.089	walking	0.082	pass	0.076
8	road	0.061	breach	0.083	bicycling	0.081	road	0.073
9	station	0.059	use	0.075	prefectural police	0.075	sidewalk	0.071
10	give	0.059	last year	0.068	manner	0.071	bicycling	0.068
11	many	0.055	walking	0.068	use	0.069	rule	0.068
12	counter measure	0.055	in the prefecture	0.064	in the prefecture	0.058	prefectural police	0.068
13	last year	0.054	manner	0.062	pass	0.057	walking	0.067
14	surround	0.054	guidance	0.058	guidance	0.057	last year	0.067
15	sidewalk	0.052	many	0.053	run	0.057	***roadway***	0.062
16	riding	0.048	rule	0.051	photo	0.056	run	0.059
17	remove	0.046	give	0.050	rule	0.055	breach	0.048
18	people	0.045	in the city	0.049	***roadway***	0.053	prefecture	0.046
19	commuting	0.045	death	0.048	many	0.052	many	0.046
20	prefecture	0.044	road	0.047	last year	0.049	in the prefecture	0.045
21	run	0.042	people	0.046	junior high-school student	0.049	manner	0.045
22	in the ward	0.041	sidewalk	0.045	in the city	0.049	commute to school	0.045
23	conduct	0.041	policing	0.045	commute to school	0.048	car	0.041
24	tournament	0.041	whole of country	0.044	road	0.046	guidance	0.038
25	bicycle-parking area	0.040	pass	0.042	the station	0.045	people	0.037
26	development	0.039	run	0.042	intersection	0.045	mobile	0.036
27	prevention	0.037	counter measure	0.042	high-school student	0.042	phone	0.036
28	target	0.035	strengthening	0.040	conduct	0.040	development	0.035
29	commute to school	0.035	bad	0.039	lane	0.040	give	0.035
30	prefectural police	0.035	prefecture	0.039	whole of country	0.040	alert	0.034
31	bicycling	0.034	intersection	0.038	children	0.039	junior high-school student	0.034
32	car	0.034	conduct	0.037	alert	0.039	conduct	0.034
33	association	0.031	automobile	0.036	increase	0.038	occur	0.034
34	exclusive	0.031	this year	0.036	people	0.038	in the city	0.032
35	keeping	0.031	front	0.034	***illegally-parked***	0.037	set up	0.032
36	manner	0.030	junior high-school student	0.034	death	0.036	photo	0.031
37	rule	0.030	danger	0.033	association	0.036	exclusive	0.031
38	survey	0.030	elementary school student	0.032	car	0.035	brake	0.031
39	children	0.030	commute to school	0.030	prefecture	0.034	the station	0.031
40	whole of country	0.030	stop	0.030	receive	0.034	whole of country	0.029

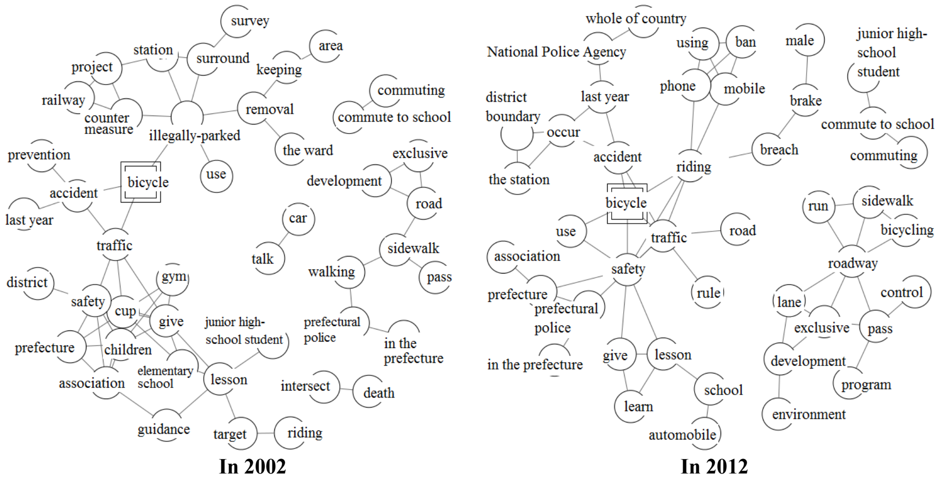
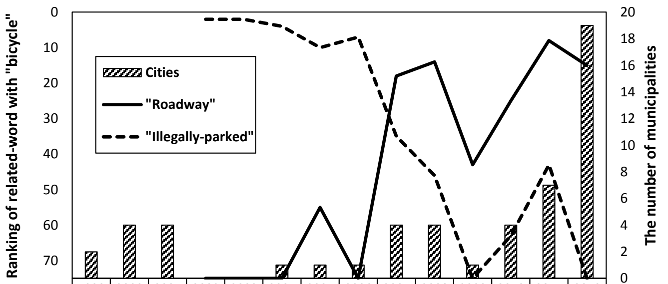


Fig. 2. Co-occurrence network of “bicycle” in 2002 and in 2012



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cities	2	4	4	0	0	1	1	1	4	4	1	4	7	19
"Roadway"				75	75	75	55	75	18	14	43	25	8	15
"Illegally-parked"				2	2	4	10	7	35	46	75	63	43	75

Year

Fig. 3. The relationship between the ranking of related words with “bicycle” from 2002 to 2012 and the number of municipalities which settled on a plan for bicycle lane network from 1999 to 2012

4.2 Co-occurrence network

Fig.2. shows the co-occurrence relationship of “bicycle” in 2002 and in 2012. The links of network represent the top 60 word pairs whose *Jaccard* coefficient were high in 483 sentences in 2002 or in 1595 sentences in 2012 (See Table.1). As shown in Fig.2., in 2002, the words “traffic” and “illegally-parked” were connected with five words including “bicycle”. In the case of “illegally-parked”, it was connected with “counter measure”, “station”, “surround” and “removal” and “use”. It means that “illegally-parked” was often used with these words on the newspaper articles in 2002. It also suggests that they represent the issue on “illegally-parked bicycle” problem. In terms of the word “sidewalk” in 2002, the word group could be found and there were seven words such as “walking”, “pass”, “development”, “exclusive use”, “road” and so on. These words suggest the issue on “development of a pedestrian road or a

bicycle path”. On the other hand, there is also the word group including “sidewalk” in 2012 and the most central word had been changed from “sidewalk” in 2002 to “roadway” in 2012. “Sidewalk” had three links with other words in 2012, while “roadway” had six links. It means that “roadway” became to be used with the words including “pass”, “exclusive use” and “lane” on the newspaper articles in 2012. And it suggests the issue on “development of bicycle lane on the roadway”. These analytical results are summarized as follows.

- The word group including “illegally-parked” represented the context of “the illegally-parked bicycle” problem in 2002.
- The word group including “roadway” represented the context of “development of bicycle path” issue in 2012.
- The context and relationship between “roadway” and “sidewalk” have been changed from 2002 to 2012.

4.3 Activities for bicycle riding in Japan; MLITT, NPA and BUPSD

In this section, the several major events on bicycle riding from 2000 to 2013 are explained. MLITT started the pilot programs in 2000, which promoted to decrease illegally-parked bicycle and developed parking area for bicycle and bicycle lane. This program had been conducted in 57 cities in Japan until 2006. MLITT set up a panel to discuss the future of bicycle riding in 2007 and also set up 98 model zones to develop a bicycle lane in 2008. Finally guideline of safety bicycle use was formulated in 2012. NPA has revised the Road Traffic Low. In 2008, the Road Traffic Law including bicycle riding had been revised. Under revised law, bicycle rider except such as disabled people need to use the roadway in principle. BUPSG was established in 2000 to diffuse the effective and safe use of bicycle riding. This group claims that both governmental agencies and municipalities need to change their policy from a comprehensive and cross-cutting perspective for safe bicycle riding. They proposed the legislation for promoting bicycle riding to diet members in 2002. They regularly hold a study meeting and encourage different parts of society to ride a bicycle safely. Especially they have strongly expressed that bicycle rider must keep to the left.
Fig. 3. shows the ranking of related words with “bicycle” from 2002 to 2012 and the number of municipalities which settled on a plan for bicycle lane network. From 2002 to 2006, the word “illegally-parked” strongly co-occurred with “bicycle”. Then the word “roadway” became to co-occur with “bicycle” more than “illegally-parked” from 2007. On the other hand, the number of municipalities which settled on a plan for bicycle lane network increased in 2011. It showed that municipalities began to recognize bicycle lane network plan as an alternative for transportation policy.

5 Discussion and Conclusion

In this study, social context is defined as wording in newspaper articles. Wording in newspaper articles on bicycle riding in Japan has been changed during the past decade. It was observed that the related words with “bicycle” have been changed from 2002 to 2012. The word group including “illegally-parked” co-occurred with “bicycle” in newspaper articles in 2002. From 2000 to 2006, MLITT conducted pilot program including illegally-parked bicycle problem. The word group including "roadway" and "lane" became to co-occur with "bicycle" from 2007. In 2007, MLITT set up a panel to discuss a safe bicycle riding and finally formulated a guideline for safe bicycle riding in 2012. The guideline includes implementation of development of bicycle lane and informs the public of bicycle rule.

There was a time lag between the change of co-occurring words in newspaper articles and municipalities' decisions. Actually, MLITT have shown the development of bicycle path as is the case with illegally-parked problem at the pilot program in 2000. Nevertheless, the word "illegally-parked" strongly co-occurred with "bicycle" from in 2000 to in 2006. It suggested that the most important problem in bicycle issue was "illegally-parked bicycle" problem. Some municipalities began to settle on bicycle lane network plan from 2011. The word "roadway" had begun to co-occur with bicycle since 2005 as shown in Fig.3. These results suggested social recognition of bicycle problem had been changed from illegally-parked problem to bicycle network planning.

As a result of our study, the change of co-occurring words was observed. The result shows two important facts. First, social context as wording in a community can be changed. Second, municipalities' decisions were affected by the change of social context. Our analytical results have some implication for participatory planning process. We need to consider social context in generating the set of alternatives. If the planner does not focus on the issue of illegally-parked bicycle in local traffic planning in 2002, there is a gap between the planning process and social context. This is because the issue of illegally-parked bicycle had higher social priority in 2002. This social context was observed from the co-occurrence words in the newspaper articles in this study. On the other hand, when planner generates the alternatives in 2012, it would be better to focus on "the development of bicycle lane" and "the promotion of the rule of bicycle riding," because they have higher social priority in 2012 as shown co-occurring words.

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SELECTING THE FIELD HOSPITAL PLACE FOR DISASTERS: A CASE STUDY IN ISTANBUL

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Abstract. Increasing population growth and lack of enough medicine care is the most important problem for the disaster managers within disasters such as earthquake. The case study is located in one of the most important and populate district of Istanbul which is called Besiktas. Istanbul is located in an area that has a high probability of an earthquake. Importance of disaster preparedness, the effects of disasters in previous years, and importance of medical services in case of emergency persuaded us to select a proper place for emergency field hospital. In this case we use Multi-Criteria Decision Making (MCDM) and Geographical Information System (GIS) together for providing the process which combines GIS with Analytical Hierarchy Process (AHP) to determine the optimum site for field hospital in the Istanbul urban area. We use the criteria that are defined as Distance from Arterial Routes, Distance to Existing Hospitals, Population Density, Time of Operate, and Capacity of Beds.

Keywords: GIS, Geographical Information System, Analytical Hierarchy Process, AHP, Emergency.

1 Introduction

All of people make decision in daily life with their information unconsciously. Namely word everybody are decision maker in the daily life by evaluating events based on their information that are obtained from occurrences. Sometimes we have too much information but it will not be guarantee for making true decision, information must not be little or much, it must be enough and suitable for making decision (Saaty, 2008). The characteristic of the decision making should be simple, be adapted to group and individuals, be understandable for us naturally, encourage the reconciliation and the unanimity, and should not request for skilful person by deep detail information (Saaty 1982). MCDM problems have multiple attributes that are

referred to the goals or decision criteria of MCDM problems and show different dimensions of alternatives which can be considered (Triantaphyllou, 2000).
The main goal of Multi-criteria Decision Making (MCDM) is to help person who is decision maker (DM) for having the best choice among the number of alternative and multi criterion priorities. Erden and Cooskun (2011) said “The multi-criterion choice can be attributed to many spatial decision-making problems involving search and location/allocation of natural resources. These problems, often analysed in GIS, include location/site selection for: service facilities, retail outlets, critical areas, hazardous waste disposal sites and emergency service locations”. Site selection with the MCDM method has four steps are defined as (i) definition of criteria, (ii) expression of relevance of criteria in the respect of decision making process, (iii) improving the sites that are selected as alternatives in MCDM problem, and (iv) defining the pairwise matrices and evaluating alternatives and making decision for site selection problem (Ertugrul and Karakasoglu, 2008).
Hazard is a physical event with potential damage that causes loss of life or injury, property damage, social economic disruption or environmental degradation. Hazards may not visible at the time, and it shows its effects in future with deferent origins such as natural events or by human activities or both, such as environmental degradation or technological hazards. Hazard may accrue by single origin and effects, sequential or combined. Any hazard will define by location, intensity, frequency and probability (UN/ISDR 2014).
Disaster defines as a terrible event that is disrupted the functioning of community or society seriously. It causes human, material, and economic or environmental losses that improves the ability of community or society to cope using its own resources. Disaster is a phenomenon that can cause damage to life and property and destroy the economic, social and cultural life of people. Hazards have different origins and cause disasters. By considering to their origins, disasters will be classified in three groups as natural disasters such as earthquakes, typhoon, tropical cyclone, volcanic eruption, flood, drought and wild fires; technological disasters such as industrial accidents, transport accidents and bomb explosions; and man-made disasters are included war and terrorist activities (Mansourian, et al, 2006). When a disaster is happened, the result of interaction between vulnerabilities and disaster hazards causes injuries and loss of human lives. In this situation, some hospitals and medical facilities will destroy thereby establishing emergency health services is critical. (IFRC, 2014).
Importance of disaster preparedness, the effects of disasters in previous years, and importance of medical services in case of emergency persuaded us to select a proper place for emergency field hospital with using GIS and AHP methods.

2 Theoretical background

2.1 Analytical Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is preferred for the site selection problems which is developed by Saaty (1980).
The AHP procedure generally involves six steps (Lee et al., 2008; Vahidnia et al. 2009):

1) Define the unstructured problem. The problem should be define clearly and the alternatives and criteria should be included.
2) Decompose the problem into a hierarchical structure. The AHP decomposes a complex problem into a decision hierarchy which is much like a decision tree.
3) Employ pairwise comparisons. Decision elements at each hierarchy level are compared pairwisely, and relative ratings are assigned. Saati (1980) recommended the use of nine-point scale to express preferences between elements as equally, moderately, strongly, very strongly, or extremely preferred (with pairwise weights of 1,3,5,7, and 9) and value of 2,4,6, and 8 are intermediate values.
4) Calculate the maximum eigenvalues and eigenvectors. In order to estimate the relative weight of the decision elements in a matrix, the priority of the element is compared by the computation of eigenvalues and eigenvectors with formula 2.1:

$$A.W'=\lambda_{max}.W' . \qquad (1)$$

5) Check the consistency of the matrices. The consistency ratio is applied to examine the consistency of judgments in the pairwise comparison. The consistency index (CI) and (CR) are defined as formulas 2.2 and 2.3 (Saaty, 1980)

$$CI = (\lambda_{max} - n) / n-1 . \qquad (2)$$

$$CR = CI/RI . \qquad (3)$$

6) Obtain an overall rating of decision alternatives by aggregating the relative priorities of the decision elements. An overall priority ranking of the decision alternatives can be obtained by combining the criterion priorities and priorities of each decision alternatives relative to each criterion (chen et al., 2006)

2.2 GIS and site selection

Vahidnia et al. (2009) said that "During the last few years, GIS has been used as a system for management, manipulation, representation and analysis of geospatial data to facilitate and cut down costs in the site selection process." The general goal of site selection problems is to find the best location which is optimum about satisfying the problem's criteria (Healey and Ilbery, 1990). The site selection process has two stages that are defined as screening for defining alternative from large geographical area and evaluating of alternatives for selecting optimum site (Chang et al., 2008).

Some tools ad systems are useful for site selection problems such as Expert Systems (ES) for well-defined and structured problems and Decision Support System (DSS) for ill-structured problems or their combination (Vahidnia et al. 2009). But for ill-structured or semi-structured problem, combining GIS and MCDM techniques can simplify the process of site selection (Zucca et al., 2008; Chang et al., 2008; Witlox, 2005; Vahidnia et al. 2009).

3 Methodology and Analysis

3.1 Methodology

The main objective of this study is introducing the specific model in order to site selection for field hospital. This model support decision makers in multi-criteria decision making problems which apply AHP method with multiple decision makers. The methodology is used in this study includes these steps that are fallowed and depicts in the Fig 1.

(i)Define problem, definition of the problem/objective (site selection for field hospital). (ii) Define criteria, identification of the potential criteria for finding the optimal sites of field hospital. (iii) Data collection, collect and prepare data which are used in the GIS as inputs. (iv) Basic maps, create raster datasets that produce basic maps of GIS. (v) GIS analysis, classification of raster datasets that use as basic information about problem for decision makers. (vi) Define preference matrices, three experts who are related to the disaster management decision making groups evaluated preference value to the relevant criteria and make preference matrices. (vii) Using AHP method, analysis the results obtained from AHP model. (viii) Determine optimal location, define specific model and prioritize the criteria for selecting best place for field hospital.

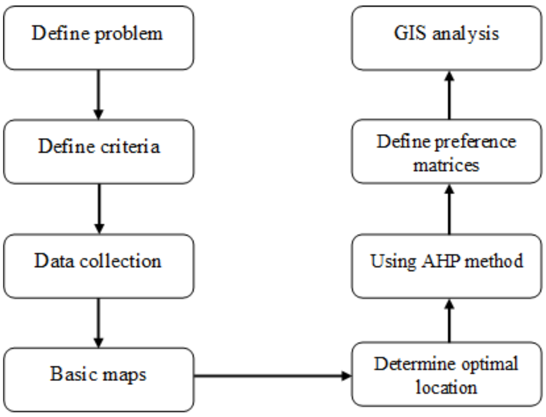


Fig. 1: The flow chart of the methodology in this study.

3.2 Definition of Alternatives

The study area is located in the Istanbul that is the most important city in the Turkey. We selected Besiktas (Beşiktaş) district as a case study that is on the European side of Istanbul, by the coast of the Bosphorus. Besiktas is divided to some key locations running up the Bosphorus on the European side (from Dolmabahçe Palace up to Bebek) and the land on the hills behind these settlements. The important sectors of the besiktas are Arnavutkoy, Bebek, Etiler, Levent (all parts), Ortakoy, Ulus, and Yildiz. The population of besiktas is 1865,750 according to the TUIK 2013 and it cover an

area of 21 km2 (8 sq mi) which makes one of the smallest and important districts of Istanbul.
We have selected five alternative (parks) that are located in the different sectors of Besiktas. Our alternative define as (i) Yildiz Park in Yildiz sector, (ii) Besiktas Sanatcilar Park in the Akat sector, (iii) Cemil Topuzlu Park in the Kurucesme sector, (iv) Prof. Dr. Aykut Barka Park in the Kultur sector, and (v) Ulus park in the Kurucesme sector. The Fig. 2 shows the location of these parks in the map.

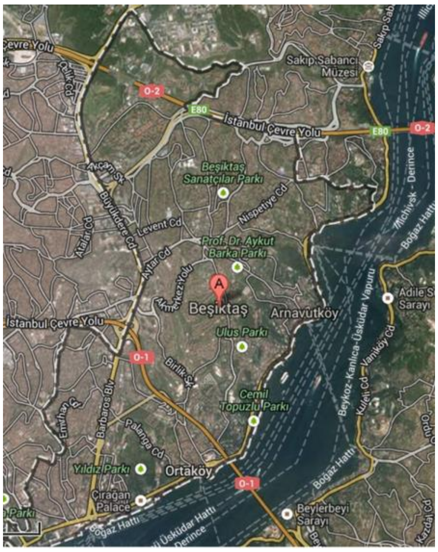


Fig. 2: The location of parks in the map (Google Map, 2014).

3.3 Definition of Criteria

Five criteria have been considered to find best place for the field hospital in the Besiktas of Istanbul as the influence factors. Field hospitals should be close to a main transport route, so the first criteria is Distance from Arterial Routes (Vahidnia, et al, 2009). The next effective factor in this study is the Distance to Existing Hospitals. In the emergency situations, field hospital after doing triage and treatment phases, it will transfer patient to the normal hospitals. Those field hospitals which close to the existing hospitals have higher score in evaluating of this factor (Erden and coskun, 2009). Another important factor is the Population Density. Istanbul is a metropolitan city and it has quite high population densities, so, it is considered as a criteria in this study (Vahidnia, et al, 2009; Erden and coskun, 2009). Also, Time to Operate is other criteria in our case study that is related to the expertise of technicans who install and setup the field hospital and its facilities. The field hospital with lower time for operate and set up the facilities have higher priory because rescue activities are mainly sensitive about time in the emergency situations. Furthermore, Capacity of Beds in the field hospital is considered as a factor because feild hospital with more beds increase the utility of facilities that used in the emergency cases.

The Fig. 3 depicts the hierarchical structure of decision-making and relationship between criteria and alternatives.

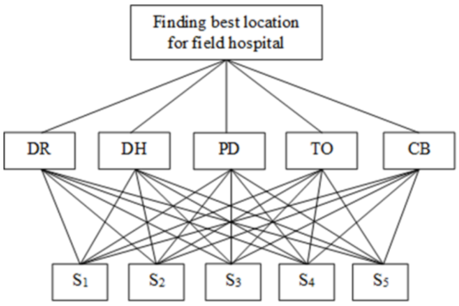
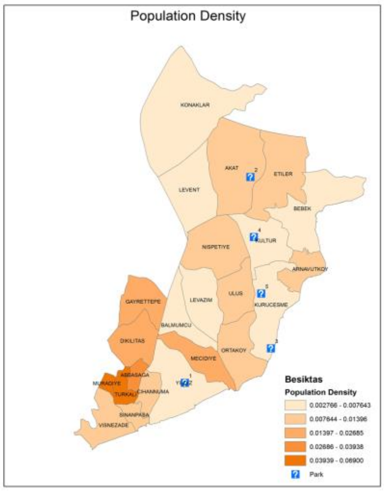


Fig. 3: The hierarchical structure of decision-making (Vahidnia, et al, 2009).

DR: Distance from Arterial Routes
DH: Distance to Existing Hospitals
PD: Population Density
TO: Time to Operate
CB: Capacity of Beds
Si: Sites (Parks)

3.3 GIS Analysis

In this study we use Geographical Information System (GIS) and the ArcGIS software 10.2 that is relate to the GIS. For using this software we need data of population that prepared from TUIK organization (Turkiye Istatistik Kurumu). Also, we obtained raster data of Istanbul maps, road network maps, and hospitals from Director of Transportation Planning of Istanbul Municipality. In addition, data of parks are obtained from Besiktas Municipality as coordinate axis. Population density is used in this study, which are obtained from dividing the census data of each sector of Besiktas by area of it. Vector-based polygon data structure is preferred for presented this criterion map layer. Fig. 4 depicts the population density in the Besiktas. Meanwhile, we changed axis data of parks to the raster-based data and made the layer of parks. In the next step, we obtained the centroid of each park and made the polygon data structure of them. Also, polygon data layer is used for distance from existing hospital and distance from arterial routes criterions. We make buffer analysis for both distance from hospital and distance from arterial routes in the different ranges. In the analysis of distance from existing hospitals, we make buffer around each hospital with range of 2000, 1500, 1000, and 700 meters. We can find from map layer the distance of each park from existing hospitals. Similarly, we used buffer around arterial routs and made map layer of distance from arterial routes in the ranges 500, 400, 300, 200, and 100 meters. The Fig. 5 present the map layer of distance from existing hospital and the Fig. 6 shows the map layer of distance from arterial routes.



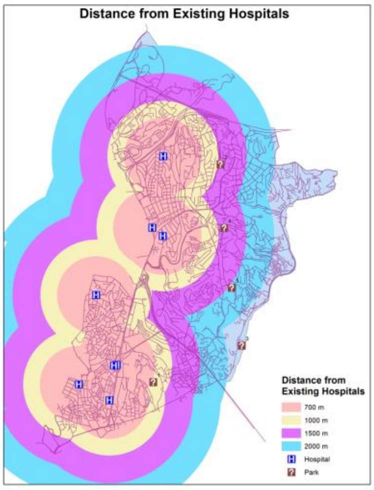


Fig. 4: Population Density of Besiktas. **Fig. 5:** Distance from Existing Hospitals.

Fig.6: Distance from Arterial Routes.

3.4 AHP Analysis

After obtaining and converting data in ArcGIS, the AHP model is considered with using Expert Choice 11 software for determining the criteria priorities and weights. We prepared a questionnaire for determining the preference matrices by experts and thereby determining the pairwise matrices by Expert Choice software. AHP helps to define the priority of the multiple decision maker's problem with. This procedure consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution (Saaty, 1989). We computed geometric means of all pair comparison judgments for each question in order to make input data for expert choice software. The Geometric Mean of data is given by the formula 4:

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 a_2 \cdots a_n}. \tag{4}$$

AHP and Expert Choice software are very strong to derive accurate ratio scale priorities because of using pairwise comparisons that performed for defining priorities. Within comparison process, the relative importance, preference or likelihood of two elements define with respect to another element. Expert choice software has three pairwise comparison assessment modes that are defined as verbal judgments, graphical judgments, and numerical judgments. Numerical judgments are made using a nine-point scale, represent how many times one element is more important than another (Fig. 7). Verbal judgments are used to compare factors using the words Equal, Moderate, Strong, Very Strong, Extreme (Fig. 8). Graphical judgments are made by adjusting the relative length of two bars until the relative lengths of the bars represent how many times more important one element is than the other (Fig. 9).

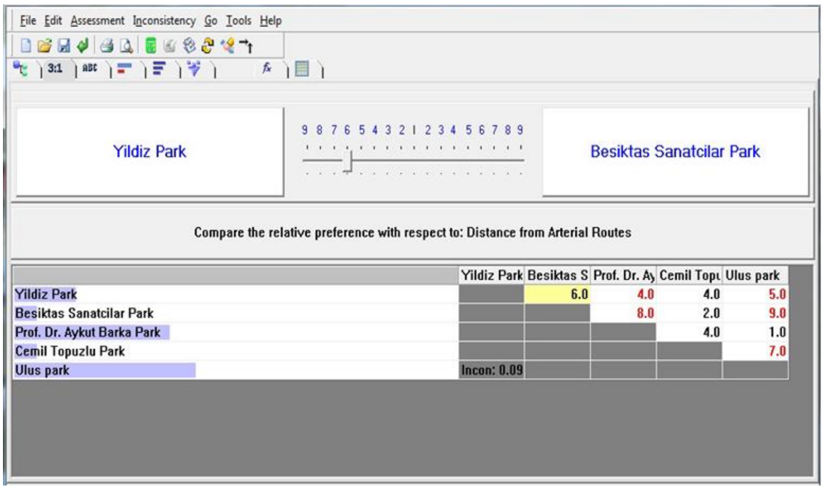


Fig. 7: The Numerical Comparison for Distance from Arterial Routes.

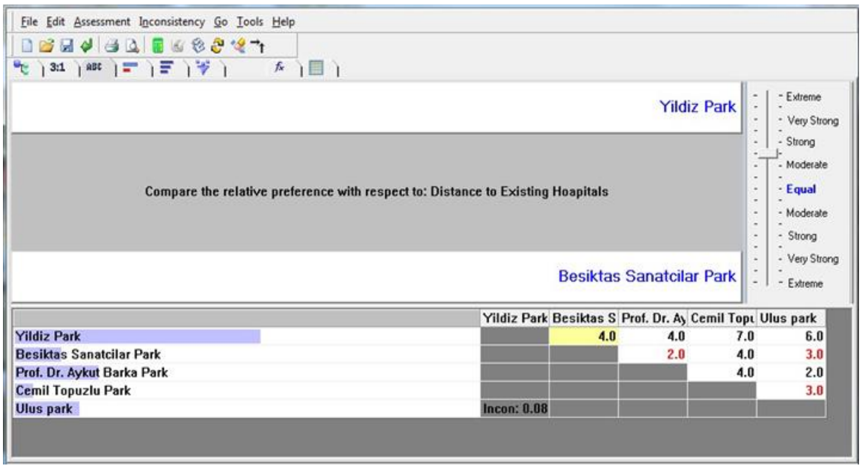


Fig. 8: The Verbal Comparison for Distance to Existing Hospitals.

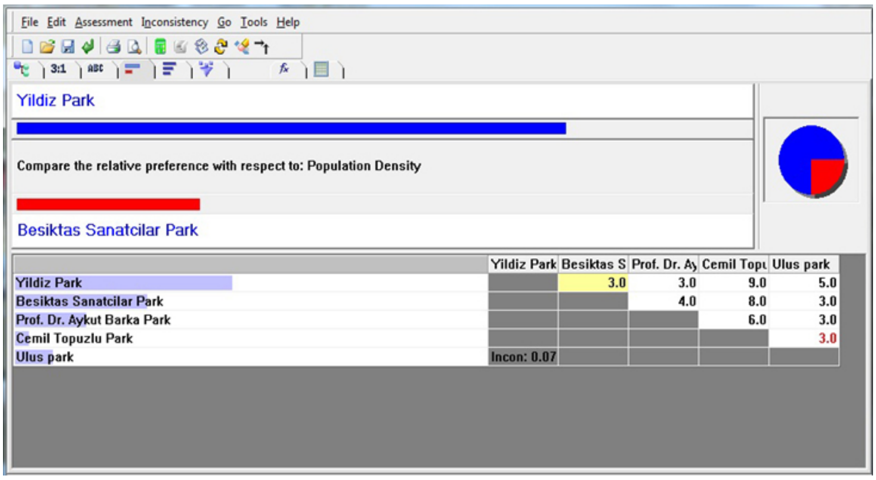


Fig. 9: The Graphical Comparison for Population Density.

At each level of hierarchy, we consider about consistency ratio (CR) of the estimated vector. If CR<0.10, then pairwise comparisons are acceptable; if, CR≥0.10, the values of ratio are indicative of inconsistent judgments. In such cases, one should reconsider and revise the original pairwise comparison matrix. In order to avoid the changing in the judgments of the respondents, only small changes are applied in this study.

3.5 Results and Sensitivity Analyses

Priorities for the alternatives have been automatically calculated by software with respect to comparison matrices of criteria which have been defined before this. The Fig. 10 shows the pairwise comparison of alternatives. As appeared in the Fig. 10 the best place for building field hospital is Yildiz Park. And Prof. Dr. Aykut Park, Besiktas Sanatcilar Park, Ulus Park, and Cemil Topuzlu Park are sequentially next priorities for bilding field hospital in Besiktas.

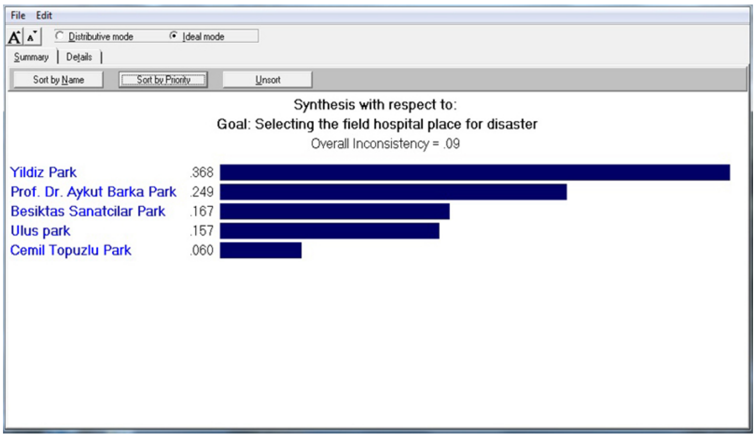


Fig. 10: The pairwise comparison of alternatives.

Dynamic sensitivity analysis changes the priority of the alternatives dynamically to define how these changes affect the priority of the alternative choices (Fig. 11). The Performance sensitivity analysis shows how the alternatives which were prioritized have relations with other alternatives by respect to each objective as well as overall (Fig. 12). The Gradient sensitivity analysis shows the alternatives' priorities with respect to one objective at a time (Fig. 13).Head-to-Head sensitivity analysis shows how two alternatives compared to one another against the objectives in a decision (Fig.14). Two-Dimensional (2D Plot) sensitivity analysis shows the alternatives' priorities with respect to two objectives at a time (Fig. 15) (Expert Choice, 2014).

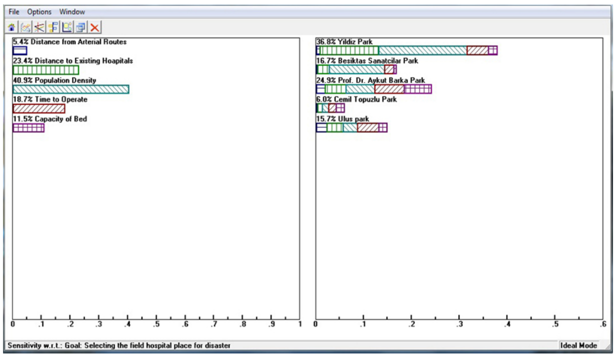


Fig. 11: The Dynamic Sensitivity with component option.

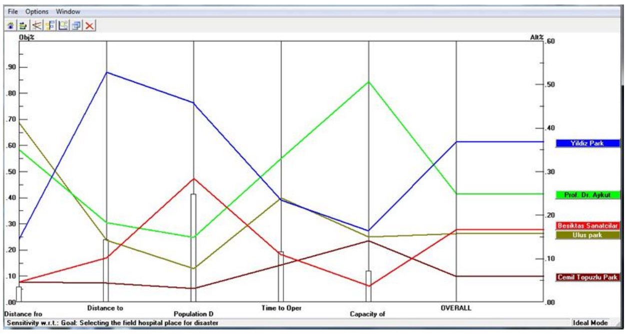


Fig. 12: The Performance Sensitivity.

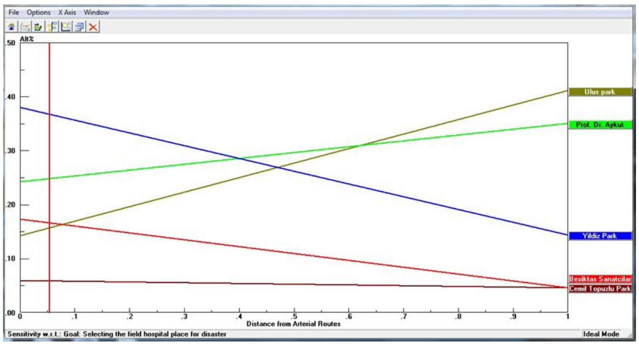


Fig. 13: The Gradient Sensitivity.

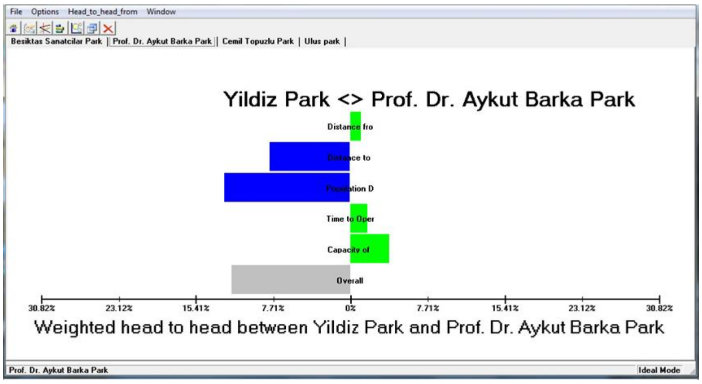


Fig. 14: The Head-to-Head Sensitivity.

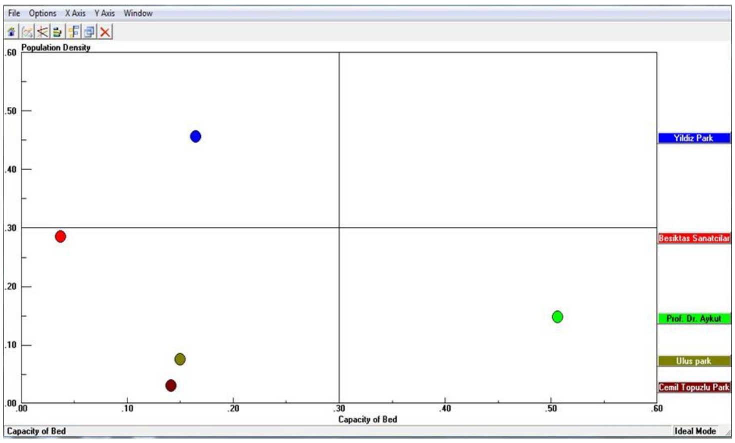


Fig. 15: The Two-Dimensional sensitivity.

4 Conclusion

This study combined AHP and GIS to define the model to determine optimal field hospital location. In this study, the alternatives are defined, the criteria for selecting best location for field hospital are determined, the roles of AHP and GIS in estimating the optimal site are explained, and the results of case study for selecting best place of field hospital in Besiktas, Istanbul, Turkey are presented. We define the priorities of criteria by the helps of three disaster management academician who evaluated our factors in this case study. Facilitating of finding best place for field hospital is resulted by combining the decision support methodology of AHP with powerful visualization of GIS. This combination provides strong abilities to analyzing the alternatives of field hospital site selection by improving the disaster management capabilities for making decision in the disaster. We study on AHP and GIS interaction in the emergency management and achieve specific model by considering of these three subjects at time. For making decision in emergency situation, accurate definition of criteria and evaluating and analysis are very vital for emergency response. This study provides strong visualization maps by GIS for having better analyzing and thereby progressing in MCDM process. This model improves decision making process in disaster and the emergency response to decrease the loss of human life and property (Erden and coskun, 2009). In the future study we will focus on Fuzzy Analytical Hierarchy Process (FAHP) for making decision in the emergency situation with GIS interaction.

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PART XI

Posters

Notes on leadership identification in Social Cognocracy Network

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Abstract. The Social Cognocracy Network is a social network developed by the Multicriteria Decision Making Group (GDMZ) that is based on the principles that support the model of democracy known as e-cognocracy. It aims to respond to one of the most important weaknesses found when citizens are incorporated into public decision making and the joint construction of a better society: the lack of citizen participation. The network considers three levels of interaction: information, content creation and decision making. E-cognocracy uses two rounds in order to incorporate preferences through an e-voting module and an intermediate round of discussion in which the arguments that support the individual positions are added by means of a forum. In the voting rounds the priorities associated to the alternatives are compared on two separate occasions; in the discussion step, the arguments for and against these alternatives, which are defended by the decision makers, are incorporated by posting messages and comments to the messages. In addition to the text that contains the decision makers' arguments, each post provides three quantitative measures that reflect the importance given by the author and the reader to the post and the extent of their agreement with it. All this quantitative information and the relationships and influence indicators within the discussion network are used to propose a procedure for the identification of the social leaders - the people whose opinions influence the actions of others.

Keywords: Policy Making, Social Cognocracy Network, Multi-Actor Decision Making, Leadership identification.

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Bayesian Models for AHP-Negotiated Decision Making

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Abstract. The Analytic Hierarchy Process (AHP) is one the most widely used discrete multicriteria decision making techniques, with one or with many decision makers. In the latter context (multiactor), three different situations are identified: Group Decision Making (GDM), Negotiated Decision Making (NDM) and Systemic Decision Making (SDM). The second situation (NDM) is characterized by the existence of several decision makers that solve a specific and common problem in an individual context; this is followed by a search for regions of agreement and disagreement among the multiple actors involved in the resolution of the problem. This poster presents a number of Bayesian models for dealing with AHP-NDM in a global context, that is to say, a hierarchy. Its operative support uses: (i) the Bayesian Prioritization Procedure (BPP) proposed for a local context (one criterion) by Altuzarra et al. (2007) and (ii) Monte Carlo simulation techniques. The new approach has been applied to several case studies taken from the scientific literature. Their results are compared with those obtained from other multicriteria approaches in the AHP context.

Keywords: Multicriteria, Multiactor, AHP, Bayesian Analysis, Negotiated Decision Making.

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Notes on the Precise Consistency Consensus Matrix

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Abstract. Firstly, this paper extends the decisional tool named *Precise Consensus Consistency Matrix* (PCCM) to the case of decision makers with different weights. Secondly, taking into account that one of the critical points of this decisional tool is that for some problems it is not possible to achieve a complete matrix because the consistency interval judgments of all the decision makers have a null intersection for one or more entries of the matrix, we analyse different options for achieving a complete common consensus judgement matrix, or for (at least) obtaining a matrix with the minimum number of entries that are required to derive the priorities. Finally, we compare the results obtained when applying the PCCM with those obtained using two traditional procedures (AIJ and AIP) in group decision making with the Analytic Hierarchy Process (AHP-GDM). In order to do this, we use a set of indicators that measure the consistency of the group pairwise matrices and the compatibility between the individuals and group positions with the analysis of the individual judgments and the group priorities.

Keywords: Analytic Hierarchy Process (AHP), Group Decision Making (GDM), Precise Consensus Consistency Matrix (PCCM), Compatibility, Consistency.

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Decision Support System for Coalitional Analysis in the Graph Model with Unknown Preference

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A new decision support system based on matrix representation for coalitional analysis under unknown preference is designed for analyzing and solving conflict when some decision makers cooperate. Unknown preference has been incorporated into the graph model for conflict resolution to analyze coalitional stabilities that were defined logically. However, as was noted in the development of the decision support system GMCR II, the nature of logical representations makes coding difficult. In this paper, four basic coalitional stabilities, CNash, CGMR, CSMR, and CSEQ, indexed a,b,c, and d, under unknown preference, are expressed using matrix forms. Compared with existing graphical or logical representation, matrix representation for coalitional analysis is more effective and convenient for computer implementation and for adapting to new analysis techniques. Therefore, an integrated decision support system with the function to analyze these coalitional stabilities under unknown preference is developed. Existing decision support system GMCR II, is available for four basic stabilities and Nash coalitional analysis within simple preference only. The new decision support system may deal with more complex strategic conflicts containing coalitional analysis within unknown preference. The new system is illustrated in this paper using an international environmental dispute, called the Gisborne Lake conflict.

Preference Awareness in the negotiation preparation of teams for fostering joint team priorities as a precondition for integrative bargaining

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Conflicts between groups, e.g. different companies or nations, are omnipresent. Particularly when issues are complicated, teams are brought into play to reach a resolution of the conflict through negotiation. A major problem within a negotiation team is, that its members - although they form one joint negotiation party - often have different preferences for an upcoming negotiation. If these aren't exchanged and aligned by the team members *prior* to the negotiation in order to agree on joint priorities, they achieve poorer negotiation results for their team, especially when there is integrative potential. Besides the fact that teams often insufficiently prepare for an upcoming negotiation, various collaboration barriers hinder the proper exchange and alignment of team members' preferences within the team, especially when the team cannot meet in person but prepares computer-supported. Findings on Knowledge and Information Awareness show, that group members reach better computer-supported collaborative problem solving when they are informed about the knowledge and its underlying information of their collaborators. Based on these findings, the concept of *Preference Awareness* was developed by the first author, defined as being informed about the other team members' preferences for an upcoming negotiation. This experimental study examines whether computer-supported Preference Awareness during the negotiation preparation – compared with a condition without awareness - fosters the exchange and alignment of preferences within negotiation teams and thereby leads to a better knowledge about the joint team priorities among the team members. In a further awareness-condition, the team members cannot communicate with each other, in order to test if communication - apart from being informed about the other team members' preferences - has any impact on the alignment of the preferences. In the conditions with Preference Awareness each member has access to the preferences of all team members for nine different attributes of the negotiation issues in a spreadsheet. In the condition without awareness each team member can only see his/her own preferences. The values for the preferences can range from 0 to 100 and are graphically supported by different sized bar charts. It is subsequently tested, how well the single team members can judge the importance of each negotiation issue for the whole team. This serves as an indicator of whether the team members know which profitable trade-offs could be made for the whole team, representing it in a negotiation. The results of this study will be presented at the conference.

PART XII

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