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THE NEED OF FAIRNESS IN GROUP CONSENSUS REACHING PROCESS IN A FUZZY ENVIRONMENT

KONCEPCJA „SPRAWIEDLIWOŚCI" W PROCESIE OSIĄGANIA KONSENSUSU W GRUPIE W WARUNKACH ROZMYTOŚCI

Abstract

In this paper we explain the need of "fairness" in the human-consistent computational system which supports a group consensus reaching process. We propose the model which combines mathematical approach based on fuzzy environment, i.e. "soft" consensus developed by Kacprzyk and Fedrizzi and socio-psychological approach concerning fairness component. We view fairness from two possible perspectives: a fair distribution and a fair final decision. Finally, we confirm our assumptions by observations in the analyzed groups of students.

Keywords: group consensus reaching process, decision support systems, fairness, fair resource allocation, soft consensus

Streszczenie

W niniejszym artykule wyjaśniono potrzebę „sprawiedliwości" w systemie obliczeniowym wspomagającym proces osiągania konsensusu w grupie decydentów. Autorki zaproponowały model łączący podejście matematyczne oparte na środowisku rozmytym oraz czynniki społeczno-psychologiczne wyjaśniające opisywaną koncepcję. Pojęcie „sprawiedliwości" rozpatrywane jest tu w dwóch kategoriach: rozkładu zasobów oraz decyzji ostatecznej. Założenia poparte są wnioskami na podstawie obserwacji grup studentów.

Słowa kluczowe: proces osiągania konsensusu w grupie, systemy wspomagania decyzji, sprawiedliwość, sprawiedliwy rozkład zasobów, miękki konsensus

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1. Introduction

Decision theory is an interdisciplinary domain which combines research from many disciplines, i.e. psychology, sociology, economics, philosophy, political science, etc. The formal direction can not be the only course of decision making problems since all the classical methods have a very limited capacity for explaining empirical choices.

Regardless of its origin, the essence of decision making process is always the same: there are some options to choose between and the choice is made in a goal-directed way [6]. In fact, many different models of decision making process occurred and enriched an analysis of human behavior, social interactions and other socio-economic descriptions depending on the respective purpose. All of these novel agent-based computational models appeared in order to make the process more human-consistent and believable. That is the reason why we decided to apply psychological and sociological theories to investigate and design systems in this research topic.

By the same token, the concept of fairness appears to be a multifarious issue which draws upon ideas from a whole panoply of scientific disciplines. The prevalent aspect, however, is the impossibility to achieve an ideally fair distribution of power in the decision making process. Deviations of behavior from the presumed results in decision making process suggest and also confirm that fairness influences decision making process.

Groups of individuals are known to be effective organs in decision making process. In spite of several dysfunctions of group work, there still are more crucial benefits (process gains). Namely, groups are better than individuals at understanding problems, at catching errors, so they provide learning. Moreover, a group has more information than any member and can combine this knowledge to derive better solutions and stimulate the creativity of participants and the process itself. Hence, the *group decision making process* will be the groundwork of our further consideration. Considering different types of groups [7] in decision making problem, we took into account *interpersonal orientation group*. It means that one in which the final solution of the problem is only a minor goal. Here, the priority is to ensure a good relation among group members during decision making process and to achieve consensus in the sense of some satisfactory agreement as to the chosen option.

We want to guarantee an equal participation of all decision making members in the consensus reaching process. In most cases, there is also a small group of outsiders who are isolated in their opinions as to the rest of the group and are omitted. Significantly, outsiders do not feel the satisfaction of discussion, what affects the effectiveness of an entire group. Of course, it does not exclude the final decision achievement, but decreases the opportunity of many further activities, i.e. practical implementation of the final decision, survival of the group in the long time period, etc.

All of the socio-psychological aspects forced us to seek a novel approach of consensus degree which will consider the satisfaction of every individual throughout the consensus reaching process. In Section two we will briefly present the overall structure of consensus reaching process. Section three shows an explanation of group decision support systems with a wider description of a moderator who plays here the main role. Furthermore, we attempt to reduce the complexity of the proposed system with a detailed description of relevant aspects only. In the previous work [3], we mainly focused on performance of the core of multistage model of consensus reaching process under fuzziness. In the light of the fact that most human behaviors have not been formalized mathematically yet, our purpose in this paper

is to get a better understanding of how social mechanism in group decision support systems works. Therefore, in Section four we will name some psychological studies and sociological explanations of actual fair behavior and confirm them with our observations in the analyzed groups of students. For comparison, we investigated the problematics of fairness in its versatility on the example of a study of two groups of students. An analysis of the problem of fairness in the groups of students undergoing an examination shows the manifold factors involved in the assessment of what kind of behavior is fair and what kind is not, and how to achieve fairness in decision making process. Our proposal concerning division of fairness approach in two possible directions: a fair distribution and a fair final decision is described in Section five and six respectively.

2. Group consensus reaching process

Basically, we assume the following settings: there is a finite set of individuals (experts, agents) and the finite set of alternatives (options). Experts openly express their preferences by means of pairwise comparison as to the every pairs of available options [13]. What matters here is that the main goal of group decision making process is to find a solution that all decision makers are willing to support [2].

Decision making problem is an iterative and interactive process which includes several different levels, i.e. aggregating all individual preferences into one common decision, elaborating on the agreement in the spirit of consensus reaching process etc. Reaching consensus requires: time, active participating of all members, creative thinking and being open-minded, active listening, considering ideas, feelings and situations of every participant. The model of consensus reaching process is manageable only if individuals are able to negotiate and change their preferences, thus they are willing to support.

Consensus is reached when each expert in the group agrees to support the selected final decision, though it may not have been his or her first choice. It forces the group to consider all aspects of a problem and voice objections to possible alternatives [2]. Hence, the main part of this process is discussion, which gives the opportunity to exchange knowledge, clarify point of view, defend own preferences or to become convinced to different opinions. Any member can block consensus. That is why these kinds of decisions are more difficult and complex than others. Thus, to achieve the main goal, we assume that individuals are “committed to reaching consensus” – they are expected to iteratively update their testimonies, and as a result to finally attain a satisfactory agreement. We assume the topological approach of where agreement is measured on the basis of distance between individuals during every stage of the process. Initially, experts disagree in their preferences, so they are far away from consensus. The aim is to minimize this distance, and consequently lead the group closer to the acceptable agreement [14]. What matters here, is that these initial differences of opinions are a strength of the group and a key to gather additional information, clarify issues and force the group to search for better solutions with bigger benefits for everyone [2].

3. Group decision support systems for consensus reaching

Since the development of modern technology, computerized support in making decision has enormously progressed. Today's tools are flexible, efficient, easy in use and allow to create an interactive user-friendly interface to view data, configure models, etc. This class of computer-based information systems including knowledge based systems that support decision making activities is defined by one term – *decision support systems*. They combine the intellectual reserves of individuals with the proficiency of computer to enhance the quality of final decision [16, p. 13]. Similarly, *group decision support systems* mean interactive, intelligent, computer-based systems that facilitate solution to unstructured problems by a set of decision-makers working together as a group. Unstructured problems are "fuzzy, complex processes to which there are no cut-and-dried solution methods and where human intuition is often a basis for decision making [16, p. 11]." Software products provide collaborative support to groups, i.e. supply a mechanism for teams to share opinions, data, information, knowledge, and other resources. What matters here is that group decision support system is an adjunct to decision makers to facilitate their decision making process but not to replace their judgments. Moreover, it is a dynamic system which is adaptive over time, therefore, decision makers should be reactive and able to change their opinions quickly. Group decision support systems attempt to improve the effectiveness of decision making (accuracy, quality) rather than its efficiency (the cost of making decisions).

The key to success is to create more *human consistent* and *human centered* tools and techniques to grasp and deal with difficult (decision making type) problems. These systems should provide computational tools, cognitive aspects and social dimension. In the GDSS consideration it means that a computer asks a group to solve a problem, then collects, interprets and integrates the solutions obtained by humans.

The main role of this computer-based system plays *moderator* or *facilitator* who takes care of running the whole discussion process. Moderator constantly measures distances between individuals and checks whether consensus is reached or not. Moreover, his most important task is to support the discussion, i.e. he stimulates the exchange of information, suggests arguments, convinces decision makers to change their preferences, focuses the discussion on the issues which may resolve the conflict of opinions in the group. This is repeated until the group gets sufficiently close to consensus, i.e. until the individual fuzzy preference relations become similar enough, or until we reach some time limit [11]. Doubtless, the moderator affects the general sense of satisfaction within the group and has a direct influence on the quality of final decision. What matters here is that he only tries to persuade proper experts to change their opinions and suggests some rational arguments – he does not force, argue or push individuals to change their testimonies.

Our task is to develop and enhance the discussion part and provide the moderator with a specific knowledge about group members. Briefly speaking, we want to facilitate the work of moderator, provide him with some useful guidelines and additional indicators and, as a result, make the consensus reaching process easier, faster, more effective.

4. Notion of fairness in the consensus reaching support systems – a socio-psychological explanations with observations in the analyzed groups of students

One of the definition of *fairness* says that "fairness means the satisfaction of justified expectations of agents that participate in the system, according to rules that apply in a specific context based on reason and precedent [19]". Fairness is an intricate idea that depends on many factors, e.g.. cultural values or the context of the problem. It combines many different research areas such as mathematics, philosophy, economics and other social sciences, especially social psychology. The last research area is crucial because it gives an answer to a question: "how people understand fair behavior [18, p. 15]?" Generally, fairness is understood as equality and becomes an essential element of the new agent-based computational models which aim at explaining actual behavior. Thus, another question arises: whether one can talk about a simple unified principle which could possibly solve the quandary of decision making process? The range of factors influencing the equilibrium in a group usually turns out to be versatile and depending on group dynamics, psychological and situational, as well as personal characteristics of group members. The overall idea is that subjects may be simply prejudiced in their understanding of fairness. Opponents in the decision making process may be attuned to a different perception of fairness, which impedes decision making process, or causes that consensus becomes impossible. Group decision making is usually dependable upon the actual state of emotions pervading the circle of people who set themselves a task of reaching consensus.

Our analysis of group behavior in two groups of students consisting of 14 and 12 members respectively (group A and B – students of the third year at the Department of Automatic Control and Information Technology, Faculty of Electrical and Computer Engineering, Cracow University of Technology) allowed to draw the following conclusions. It was noticeable that if at least some people in a group cared about equity, consensus was reached more quickly and the decision making process became smoother. The second of the analyzed groups (B) showed a slightly more consensus prone character. The distinctions between the standpoints of the individual agents and subgroups were not so sharp as in group A. The major factor in reaching consensus in a smoother and quicker way in group B than in group A was a lower state of psychological agitation characteristic of the group, and a calmer, less aggressive level of communication. In its major part, the group consisted of agents with much less individualized personalities, and a better developed sense of cooperation resulting in a subsequent faster implementation of the final decision.

The other crucial and decisive factor in reaching consensus in this group was a very efficient cooperation in small subgroups. The individuals in group B usually exerted a much more open attitude to the preferences of other individuals, and were less likely to fall prey to a self-serving bias. The overall mechanism of the functioning of this group and reaching consensus process was based on a very conspicuous supportive system of the presentation of ideas and the skillful putting forth of the carefully selected arguments. Generally speaking, most of the members of the group showed a relatively high level of emotional intelligence allowing to analyze almost emotionlessly the arguments stated by their opponents. What was also well observable was the fact that some members of group B exerted a strong positive influence on the entire group by exhibiting good diplomatic and negotiating skills. Two of the agents in this group were extremely flexible in swift changes of the communicative strategies they deployed to invigorate the other members of the group to share the most exposed and most successfully supported opinion.

The explanations as for the behavioral patterns in this group can be supported by the definition of the *cooperative game theory* which virtually is a game where players can enforce fair behavior. Cooperative game theory is connected with the distribution of benefits that a group of agents achieves from cooperation. The model assumes that the group of individuals wishes to solve a common problem and by cooperating they can solve the problem more efficiently [18, p. 56]. In fact, research in psychology has shown that in group situations, decisions of individuals are influenced by motives such as "group performance, sense of responsibility for others, or social concerns [18, p. 61]". It is also worth noticing that a greater level of fairness and more successful achievement of goals in decision making process were attributed to some characteristics of the observed groups such as: an eagerness to learn the actual differences between their own opinions and those of the opponents, and an ability to eliminate such opinions which were impeding agreement the most. The openness and the markedly interactive character of the group relations proved to be the core of success in meeting the point of balance.

By comparison, the first group of students (A) which blocked consensus reaching process was characterized very often by an overall unwillingness to come to a satisfactory solution for all of the members, and an insistence on particular interests of mini groups, or individuals within the group. The mini groups were very assertive in expressing their opinions and often ignorant of the opinions of opponents. Sticking to the proclaimed opinions and not being open to the proposals of others, especially those which were very different ended up in an impasse of discussion and an impossibility of reaching an agreement. Quite frequent was the situation in which some members of the group showed a total disregard for the opinions of their opponents, closing themselves in a very limited mind framework. The creativity in reaching satisfactory solutions was decreased, which was not an optimistic forecast. We may assume that the diminished level of the coherence and creative unity of the group will not lead in the long run to an expected consensus, as well as a very much needed implementation of the possible solutions.

It cannot go unnoticed that the entire context of coming to an agreement is fundamentally a situational, contextual, and psychological phenomenon. Such factors as cultural unification or cultural clashes, and much in the same manner, economic differences or similar economic status may be of significance in group consensus reaching process. These elements may have influence on whether the more egoistically oriented individuals or the more fair prone agents overbalance the process of reaching an agreement. The economic element of group consensus reaching process was thoroughly examined, for instance, by Ernest Fehr and Klaus M. Schmidt [5]. In our analysis we ignored these factors focusing on other prevalent ingredients of the situational context such as, for instance, persuasive and manipulative capabilities of the group members.

In our study we observed that agents pushed equity principles which were advantageous for them more than for other parties, in particular, those which were disadvantageous to parties with great persuasion power. The first of the two analyzed groups of students showed a complexity of reactions within the small groups or subgroups in decision making process, highly dependable on psychological factors. One of the first things which were noticed proved that group behavior to some extent was in line with individual behavior of particular agents. Basically, group behavior depended on the decision rules that agents selected and used to arrive at group decision in a biased way. Another thing which was very well seen was that subgroups expressing similar standpoints within the observed groups ignored the decision

rule of their so called "opponents" – which meant that they followed the self-serving, or self-interest preference principle. What is more, a given subgroup sharing a similar viewpoint typically disregarded other subgroups and thought of themselves as if they were single agents. Above all, one must stress that expectations as for the level of fairness were often not consistent with the outcome; we expected the level of fairness to be higher.

These observations bear out the importance of the self-interest preference in group behavioral patterns. The choices of the respective members of the group underpin our theoretical assumptions as for the self-centeredness of the individuals influencing the final group decision making process.

However, psychological studies have revealed that in real life, decision makers are not as selfish as what is shown in the solutions received using mechanisms of rational choice approaches, in the sense of maximization of some utility function [6]. Experiments showed that individuals tend to cooperate and give priority to fairness over greedy behavior. *Trust game* will transparently perform this activity. In the *trust game*, A has an initial amount of money he or she could either keep or transfer to B. If A transfers it, the sum is tripled. B could keep this amount, or transfer it (partially or totally) to A. Traditional game theory suggests that A should keep everything, or if A transfers any amount to B, then B should keep all. Experimental studies have revealed that agents tend to transfer about 50% of their money and this fairness and cooperation is related to all cultures, sexes, etc [1].

With reference to our assumption that fairness means the satisfaction of expectations of agents, group decision support system should provide the sense of satisfaction among the group members during the discussion and after the process completion. According to psychological research, satisfaction of decision makers has a direct influence on higher quality of final decision and several further activities, i.e. practical implementation of the final decision or survival of the group in the long time period [15].

5. Fair share of distributed resources

In our research we mainly reflected on one of fairness judgments identified by social psychology, namely *distributive fairness* [17]. It is usually related to the distribution of resources, goods or costs, thus to *fair resource allocation problems*. Resource allocation problems are concerned with the distribution of constrained resources within competing activities so as to achieve the best general implementation of the system with respect to fair management of all the participants. Briefly speaking, the aim is to take a *fair share* of the distributed goods, thus to find such distribution that is perceived as fair by all individuals.

The overall resource allocation problem might be stated in the following way. There is a set of $I = \{1, 2, ..., m\}$ of m activities. There is given a set P of location patterns (location decisions). For each activity i, $i \in I$, a nonlinear function $f_i(x)$ of the location pattern x is defined. This function measures the outcome $y_i = f_i(x)$ of the location pattern for each activity i.

To get the individuals closer to each other (to obtain an agreement between them), there have to occur some changes in their initial preferences. The overall amount of changes in the individuals' preferences constitutes the resource. Thus, for a given set of decision makers moderator wants to allocate fairly the resource with the objective of minimizing the outcome (i.e. the distances between individuals).

The main goal of our system is to take into account preferences of every individual and get the entire group closer to the consensus with fair treatment of all the participants. We neglect the situation when the moderator gets decision makers closer to the consensus by argumentation and persuasion only aiming at the most promising directions of further discussion (those who reach consensus quickly), while individuals who are isolated in their opinion are omitted. We found confirmation of this assumption in our observations. As we observed group behavior in two selected groups there were many situations when consensus reaching process was blocked and the domineering members of the group, as well as the dominant subgroups exerting a powerful influence on the entire group caused that some individuals found themselves in a situation of a total isolation. One of the analyzed groups (group A) was likely to undergo all the distortions resulting from the self-interest prejudice. The interpersonal relations in the observed group were not good enough to overcome all the difficulties caused by the differences in opinions. Some of the members of the group were left on the margin and could not feel the satisfaction ensuing from discussion. This, in turn, brought about a situation of little effectiveness. All in all, the image of the group was negative, there were many lost opportunities of achieving consensus. Briefly speaking, moderator can not ignore the individuals who are isolated in their opinions as to the rest of the group members, quite on the contrary, he has to convince them to change their previous preferences. This attitude undoubtedly confirms one of our assumptions, namely, an importance of active participation of every individual during the entire consensus reaching process.

As we assumed, our research should be done with respect to fair distribution. The theory of distributive fairness can be applied whenever it is possible to precisely define a fair distribution problem and to find a solution that is accepted by participants (or proposed by the moderator). If we consider the distances of the individuals' opinion to the final opinion, naturally, the final opinion should be fair in the sense that the distances of the individuals' preferences to the final decision should be fairly distributed.

6. Fair final decision

While considering the concept of fairness with reference to consensus reaching process, we decided to view the basic idea of this notion from two possible perspectives. The first one, presented in the previous section, concerns a fair distribution of resources, whereas the second is directly connected with the outcome of decision making process, namely a *fair final decision*.

We define a *fair final decision* as a possibility to reach a final consensus during a series of discussions. However, the majority here refers directly to the outcome and can be defined as the *soft consensus,* a conceptual human-consistent framework proposed by Kacprzyk and Fedrizzi [9, 10], and Zadrożny [4]. The developed idea is meant basically as an agreement of a considerable majority of individuals with regard to a considerable majority of alternatives. This operational definition of consensus can be, for instance, expressed by a linguistically quantified preposition: *most of the individuals agree in their preferences to almost all of the options*, and the consensus degree (in the range [0, 1]) is computed. It means that, except none or total agreement between agents as to the chosen solution, this approach allows some partial, acceptable consistency.

Notice that to define a fuzzy majority for measuring a degree of consensus the application of *fuzzy linguistic quantifiers* (most, almost all etc.) has been performed. The computations of this relative type of linguistic quantity can be handled via Zadeh's classic calculus [20]. Regardless of the way of implementation, the main condition of this novel approach is that it definitely overcomes the conventional concept in which consensus was understood as a "full and unanimous agreement", which means that the preferences of all the decision makers should be exactly the same. Obviously, this scenario is utopian and unrealistic in practice because individuals usually expose relevant differences in their standpoints, flexibility, tendency to change opinions, etc. All of these factors generally block the group from gaining a full and unanimous agreement.

7. Conclusions

In this article we proposed a new concept of supporting group consensus reaching process enhanced by the concept of "fairness". We showed that this notion should be definitely taken into account while creating human-consistent support systems because it is strongly connected with psychology, economics, game theory, etc. and, as a result, takes cognizance of socio-psychological aspects of group behavior. In fact, it helps us understand the typical human behavior within a group of individuals and to develop more intelligent, human-centric and human-consistent systems for supporting consensus reaching in the future development.

In our research we came to a conclusion that a degree of consensus obtained by including aspect of fairness would be higher than the previous approach based solely on soft consensus with the use of fuzzy logic proposed and successfully implemented by Kacprzyk an Zadrożny [12]. We enriched our concept by the novel fairness component. Hence, we take liberty of putting forth a hypothesis that the concept of novel approach affects directly the effectiveness of decision making process, satisfaction among group members and, as the result, the quality of the final decision, which becomes highly justified. The ultimate goal of our further research is the mathematical formalization of the fair group consensus reaching process (building a model with regard to real events and psychological factors) in order to verify – confirm or reject – our assumptions.

Thus, our comprehensive approach proposed for supporting consensus reaching process under fuzziness refers particularly to a degree of agreement in a group, individual preferences of group members and the moderation of the discussion in order to gain satisfactory solutions in the more effective and efficient way. What matters here, is that we respect the fair distribution in the sense of contribution of all decision members to choose the final solution. Hence, the situation when minority must obey majority and change their opinions accordingly is in the proposed system ignored.

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References

[1] Camerer C.F., *Psychology and economics. Strategizing in the brain*, Science, 300, 2003, 1673-1675.

[2] Center for Excellence in Government, Facilitator's Toolbox, 1996, http://www.employeesu.com/docs/EmployeeResources/Creating%20Consensus.pdf, [date of access: 23.03.13].

[3] Falkiewicz D., Kacprzyk J., *Different Aspects of Supporting Group Consensus Reaching Process Under Fuzzines*, Technical Transactions, vol. 1-AC/2012, Cracow University of Technology Press, 17-27.

[4] Fedrizzi M., Kacprzyk J., Zadrożny S., *An interactive multi-user decision support system for consensus reaching process using fuzzy logic with linguistic quantifiers*, Decision Support Systems, vol. 4, no. 3, 1988, 313-327.

[5] Fehr E., Schmidt K., *A Theory of Fairness, Competition and Cooperation*, The Quarterly Journal of Economics, MIT Press, no. 3, vol. 114, 1999, 817-868.

[6] Hanson S.O., *Decision Theory: A Brief Introduction*, Philosophy, vol. 23, Royal Institute of Technology, Stockholm, 1994, 1-94.

[7] Jennings H.H., *Sociometric differentiation of the psychegroup and sociogroup*, Sociometry, vol. 10, 1947, 71-79.

[8] Kacprzyk J., *Neuroeconomics: yet another field where rough sets can be useful?*, Chac C.C et al. (Eds.): RSCTC 2008, LNCS, vol. 5306, 2008, 1-12.

[9] Kacprzyk J., Fedrizzi M., *A 'human-consistent' degree of consensus based on fuzzy logic with linguistic quantifiers*, Mathematical Social Sciences, vol. 18, 1989, 275-290.

[10] Kacprzyk J., Fedrizzi M., *A 'soft' measure of consensus in the setting of partial (fuzzy) preferences*, European Journal of Operational Research, vol. 34, 1988, 315-325.

[11] Kacprzyk J., Zadrożny S., *On a concept of a consensus reaching process support system based on the use of soft computing and Web techniques*, [in:] D. Ruan, J. Montero, J. Lu, L. Martínez, P. D'hondt, E.E. Kerre (Eds.): Computational Intelligence in Decision and Control. World Scientific, 2008, 859-864.

[12] Kacprzyk J., Zadrożny S., *Soft computing and Web intelligence for supporting consensus reaching*, Soft Computing, vol. 14, no. 8, 2010, 833-846.

[13] Kacprzyk J., Zadrożny S., *Supporting Consensus Reaching Processes under Fuzzy Preferences and a Fuzzy Majority via Linguistic Summaries*, Preferences and Decisions Studies in Fuzziness and Soft Computing, Springer, vol. 257, 2010, 261-279.

[14] Kacprzyk J., Zadrożny S., Raś Z., *How to Support Consensus Reaching Using Action Rules: a Novel Approach*, International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, World Scientific, vol. 18, no. 4, 2010, 451-470.

[15] Priem R.L., Harrison D.A., Muir N.K., *Structured Conflict and Consensus Outcomes in Group Decision Making*, Journal of Management, 1995, vol. 21, no. 4, 691-710.

[16] Turban E., Aronson J.E., Liang T.P., *Decision Support Systems and Intelligent* Systems, 6th Edition, Prentice Hall, 11-19, 2005, 94-101.

[17] Tyler T.R., Smith H.J., *The handbook of social psychology*, vol. 2, *Social justice and social movements*, McGraw-Hill, Boston, 1998, 595-629.

[18] Wierzbicki A., *Trust and Fairness in Open, Distributed Systems*, Springer, 2010, 11-19, 56-70.

[19] Young H.P., *Equity: In Theory and Practice*, Princeton University Press, 1994.

[20] Zadeh, L, *A computational approach to fuzzy quantifiers in natural languages*, Computers and Mathematics with Applications, no. 9, 1983, 149-184.