Effect of the Coordination Modes in Supporting Group Multiple Criteria Decision Making in a Distributed and Asynchronous Environment

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Abstract. To solve a multiple criteria decision problem by a collaborative group is necessary to have an adequate coordination process. This paper discusses an on-going research project, which aims to develop an internet-based Multiple Criteria Group Decision Support System (MCGDSS) – which will support to collaborative group decision makers in reaching a consensus when they try to solve a ranking problem – and to further investigate the impacts of such a system on group multiple criteria decision aid (MCDA) process performed in parallel and sequential coordination modes. Features of the MCGDSS prototype and design of a follow-up laboratory experiment are described in this paper.

Keywords. Group Decision Support Systems, Multiple Criteria Decision Aid, Ranking Problem, Coordination Modes, ELECTRE Methods.

1 Introduction

Group decision making is one of the most frequent and important processes inside of organizations in the public or private sector. Most of the problems about real decision making involve multiples decision makers [34]. The comprehension, analysis, and support of the decision making process can be extremely difficult for three reasons: 1) the basic problem is badly structured, 2) the dynamic environment in which the decision making process develops, 3) the presence of multiple decision makers, each of them with their own points of view about the way the problem has to be managed and what decisions have to be adopted [15]. The strongest obstacle to resolving a group decision problem is that each individual has his/her own perception about problem. Consequently, he/she has his/her own belief about what should be the result or the correct decision to make. Therefore, in such an environment, it is logical and common to find conflicts between the opinions and desires of the group members. These conflicts arise due to the several factors present such as different values and

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objectives, different criteria and preference relations, lack of communication support between group members, etc. [30] encapsulates the diverse factors in conflict under the term “distinct value systems.”

This paper presents a research projects that aims to develop an Internet-based Multiple Criteria Group Decision Support System (MCGDSS) prototype built around Multiple Criteria Decision Aid (MCDA) models, which provides support for group decision making processes in asynchronous and distributed environments. The project intends to investigate whether the parallel and sequential coordination modes influence the outcomes of the group MCDA processes. In this paper we briefly discuss the research method and design in our study. The MCGDSS prototype and a lab experiment design are also presented in this paper.

2 Group MCDA Process

A coordination mode refers to a series of procedures and aggregation methods, which incorporate the group and individual members activities and facilitate them to reach agreement of a high quality group decision [3]. In such an environment, each participant can sometime work individually and/or collaborate with the rest of the group at other time. These two different processes result from two coordination modes, which has named by Cao and Burstein [3] as sequential and parallel modes respectively.

The influence of coordination modes on outcomes of group decision making process, however, has not attracted much attention in previous synchronous GDSS studies. Previous research indicated that the different procedure and aggregation methods might bring about different decision outcomes when using MCDM models [33]. In a distributed and asynchronous setting, these coordination modes may have an important influence on outcomes of group decision making. Therefore, such research is necessary and it may help to find out appropriate coordination modes that will bring the individual decision making process into synchronization with the group process, without restricting the achievement of satisfactory decision performance. Cao and Burstein [3] claim that in a distributed and asynchronous setting, these coordination modes have an important influence on outcomes of group decision making, our interest in this research is validate the hypotheses proposed by Cao and Burstein under different conditions: different multiple criteria modeling approach (MCDM vs. MCDA), different platform (Domino-Lotus vs. Groove), different problem solving (selection problem vs. ranking problem) and different method (Simple Additive Weighting (SAW) vs. ELECTRE).

3 Related Works

There are a few GDSS that have used multiple criteria analysis techniques to support a group decision. Most of them have focused on communication elements, the structure of ideas, the generation of alternatives and the voting procedures. For instance, the GDSS of Conklin and Begeman [6], Cesar and Wainer [4], Lee [17] are focused on distributed and asynchronous meeting support, via an interconnected computer network. In these systems, the elements of a debate can be documented, reviewed or used again in any phase of the process, although, in contrast, they do not have structured techniques to solve problems of group decision making.

MCGDSS have emerged just in the 80's, almost twenty years after the introduction of the field of MCDA. These methodologies were identified in Iz [13], Iz and Gardiner [14], and Hwang and Lin [12]. In the early years, Bui [2] presented Co-oP, a co-operative multiple criteria group decision making system. The PLEXSYS system [8] and its descendant GroupSystems [26] contain, among others, a Alternative Evaluator tool which provide multiple criteria decision making support. After appears the Expert Choice system for group decision support based on the AHP method [31]. Also after Barzilai and Lootsma [1], [25] describe some other interesting methods of multiple criteria group decision making support. Hamlainen and Mustajoki [10] present the web-HIPRE system, which, in part, is based on the AHP. In [22] and [7] we can find another studies on MCGDSS. A similar approach to PROMETHEE MCGDSS developed by Macharis et al. [21] we can find in Leyva [18], which is based on the ELECTRE method [30].

By the way, research on the coordination modes in distributed group decision support systems has recently focused on the issue of system restrictiveness, which refers to the degree that a system limits its users decision making processes to a subset of all possible processes [32]. Another research topic has been the flexibility of coordination structure, and its influence on group decision outcomes and performances [24]. The conclusions reached in this area have been inconsistent. In studies on synchronous groups support systems, Chidambaram and Jones [5] reported that a GDSS with a high degree of system restrictiveness had negative impact on group performance. It seems that an imposed coordination structure can be overly restrictive due to the limited bandwidth of the interaction medium. Research regularly indicates that the individuals come to the group with a predetermined preference over others decision alternative and they seem relatively inflexible to following a particular decision making strategy [28]. It is also suggested that less restrictive coordination structures are more appropriate to support asynchronously interacting distributed groups [16]. Therefore, distributed GDSS should be flexible enough to allow the individual freedom to concentrate on aspects of the problems to which he or she can best contribute [35]. On the other hand, Dickson, Partridge, and Robinson's [9] research indicated that GDSS should be designed with some degree of restrictiveness. Too much freedom in group interaction decreases group cohesiveness. Such loss of cohesion increases the decision cost either by generating a lower quality decision or taking more time to make a decision. Therefore, a coordination structure in distributed GDSS should impose some restrictions on interaction to maintain a certain level of group cohesiveness. The varying outcomes may results from applying different degree of system restrictiveness [11]. So far very little is known about what objectively determines the perceived degree of system restrictiveness. Previous studies have not explicitly shown the use of MCDA to support the group decision making processes. In our study, system restrictiveness is manipulated by applying certain procedures and aggregation methods (particularly ELECTRE methods) to the GDSS process. By manipulating these procedures and aggregation methods in group MCDA we try observe the impacts of different coordination modes on group decision outcomes and performance.

4 Group MCDA Processes with Two Coordination Modes

As stated above, in this study, we considered two coordination modes: parallel and sequential. We believe these two modes mostly cover the possible ways that people can go through a MCDA process. Guided by these two coordination modes imposed to the decision making process, group may reach a right decision at a right time.

4.1 Parallel Coordination

Parallel coordination means everyone in a group works independently throughout most steps during the decision making process. The procedure and respective aggregation methods are described step by step as following:

Preliminary stage structuring the decision problem

The preliminary stage is a phase of knowledge acquisition and problem structuring. A facilitator has first to be appointed. On one hand, the facilitator has to be familiar with the GDSS-ELECTRE methodology and, on the other hand, he needs to have a reasonable knowledge of the actual group decision problem and its context. The following steps can be considered potentially.

Step 1. First contact Facilitator – Decision Makers.

Each decision maker is encouraged to express his own opinions in order to progressively enrich the maturity of the facilitator with respect to the decision process.

Step 2. Problem description.

The decision makers meet in the MCGDSS. The facilitator comments the available infrastructure and gives an overall description of the problem.

Step 3. Alternative generation.

This is a “computer” phase during which the decision makers work alone.

Step 4. Choose a stable set of alternatives.

Step 5. Comments on the alternatives.

Step 6. Define the possible evaluation criteria.

This step ends the preliminary stage and the next evaluation stages can start.

Individual evaluation stage

Step 7. The proposed alternatives are evaluated by each criterion

Step 8. Define weights and thresholds of the criteria

Step 9. The individual ELECTRE analysis

The ELECTRE III method [29] is applied to construct a fuzzy outranking relation and next a genetic algorithm [19] is applied to exploit it and as a result it recommends a complete ranking of the alternatives from the best to the worst ones.

During the first stage, each decision maker works individually, with the possible assistance of the facilitator. At the end of this stage, everybody has a good personal view of the decision problem. Everybody has ideas on how to decide. More precisely, each decision maker has a ranking of the alternatives in decreasing order of preference.

Group evaluation stage.

The purpose is now to focus on group decision support in order to take into account the specific points by view of the different decision makers.

Step 10. Global evaluation

At the end of the individual evaluation stage, the facilitator collects the rankings an fuzzy preference relations coming from the decision makers and with these information the ELECTRE GD method [20] is applied to construct a fuzzy outranking relation and again the genetic algorithm is applied to exploit it and as a result it recommend a complete ranking of the alternatives from the best to the worst ones.

At the end of the step 10, a global evaluation is obtained for the group. The (ELECTRE GD-genetic algorithm) method proposes a best compromise. If the group is agreeing upon the results of the global analysis, the best compromise can be adopted and the GDSS-ELECTRE session can be closed. On the other hand, if for some reasons some decision makers don't agree on this compromise, the conflicts have to be faced.

4.2 Sequential Coordination

In a nut shell, we can say that sequential coordination implies that consensus would be sought throughout some stages of decision making process, from problem formulation to ranking determination. The consensus may be reached by applying aggregation methods at any appropriate stage. A procedure with sequential coordination mode and ELECTRE III method is:

The group is asked to agree on the alternatives, criteria, weights, and thresholds before the model provides a ranking. The group discussion focuses on what actions and criteria should be considered, what weights and other necessary parameters are appropriate. Once the discussion is closed and all the individual information has been gathered, a technique is used for obtaining values of these model parameters, which should represent the collective opinion. With this information, the (ELECTRE III-genetic algorithm) method gives us the group ranking. It needs to be noticed that this procedure is iterative rather than simply sequential. If the group is unsatisfied with the result at any stage, it may go back to any step and redo it.

5 Research Design

The research question in our study is stated as: “ Which coordination mode between the parallel and sequential ones is more appropriate for a group multiple criteria decision aid process in the asynchronous and distributed environment?”

5.1 Research Framework

The research adopts Nunamaker et al. [27] general GDSS research model. Revised version that conforms to our research design is present in Figure 1. From this “input-process-output” system standpoint, coordination mode is an independent variable in our study. McGrath and Hollingshead [23] developed a framework that consists of four primary factors: input, organization concepts, process variables, and outcomes. Their framework stresses the interactive relations between the variables. One of the most interesting points is that the process variables can be regarded as independent or dependent variables depending on the intended purpose.

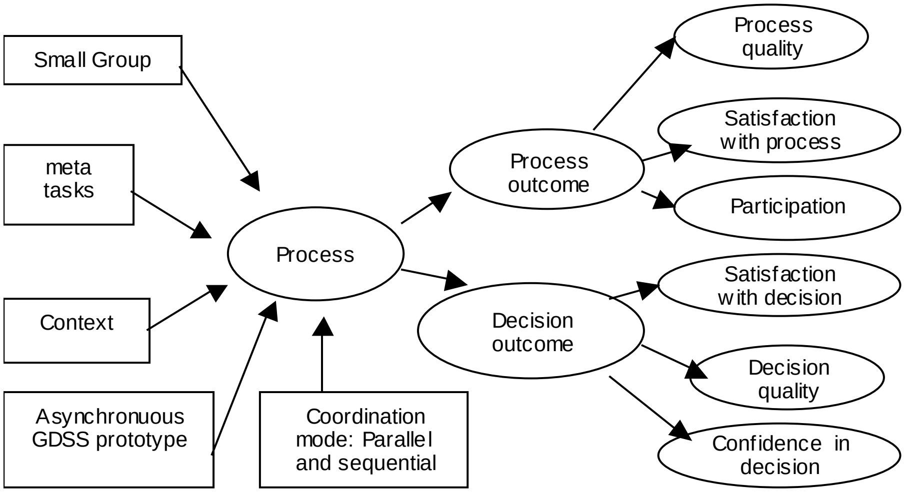

Fig 1. Research framework for adapted MCGDSS [27]

In order to answer the research question, we need to implement a GDSS, which provides appropriate procedures and tools to support the group MCDA process. It should be tailored to suit for our further investigation of the research question. Once the GDSS prototype is implemented, a lab experiment will be organized to further investigate the research question. Two kinds of subject groups will be asked to use the system prototype going through a predefined MCDA process coordinated by the parallel and sequential modes. By observing the MCDA process outcomes, which are measured by the decision outcome and the process outcome, we may find out how significant these two coordination modes might influence the process outcomes.

5.2 GDSS Prototype

System Development Environment. The prototype will be developed in Groove by using C++ and Visual Basic languages. Groove is a new groupware technology and consists of a combination of both software and services to transform the Internet into a personal medium for directing communication and interaction between some users. The Groove platform provides services and abilities of development in a wide variety for applications peer to peer. The users directly interact with each other in a real-time environment and share in an asynchronous or synchronous manner. This component has a 40% of advance.

System Architecture. The Functional architecture will incorporate the following features: The ELECTRE III model to aggregate multiple criteria individual preferences, the ELECTRE GD model to aggregate the multiple criteria group preferences, a genetic algorithm to exploit a fuzzy outranking relation, the Delphi technique to stimulate and to generate ideas, use of a facilitator tool for optimization the meetings coordination of the group members, use of a Graphic interface, use of a Database Management subsystem to allow efficient and secure information access, a Norm subsystem, a Discussion subsystem and a Multiple Criteria Decision Analysis subsystem. This component has a 60% of advance.

System Features. The prototype provides support for group MCDA process at three levels: a) Individual activity support, b) Group activity support and c) Facilitation support.

6 Laboratory Experiment Design

The objective of the experiment is to examine how the use of parallel and sequential coordination modes with the internet-based MCGDSS affects group performance in an asynchronous and distributed environment. A series of experimental sessions will be conducted with a two-group between-subjects design. These experiments based on simulated business environment are being used to evaluate the group performance affected by parallel and sequential coordination modes. The effect of each group configuration will be assessed experimentally on six dependent variables: users' satisfaction with process, users' satisfaction with decision outcomes, users' confidence in decision outcomes, quality of final decision, participation, and quality of decision process.

6.1 Subjects and Decision Task

The experimental subjects in the study will be undergraduate and postgraduate students enrolled in information systems courses. The decision task for this study will be either a case study of solving MCDA problems selected from textbook or familiar MCDA problem, which have been done previously by subjects. A pilot study will be conducted before the main study to test reliability of the prototype and complexity of the decision task, and to fine-tune both of the experimental procedure and the instrument.

6.2 Independent Variable

Coordination mode is the independent variable in the study. It has two levels: parallel and sequential

6.3 Dependent Variables and Hypotheses

Two classes of dependent variables, process outcome and decision outcome, are evaluated as the outcomes of group MCDA processes affected by two coordination modes.

6.4 Experimental Procedure and Instrument

The appropriate instruments will be used to collect qualitative and quantitative data for measurement of dependent variables. The response sheets and questionnaire are being prepared for collection of data on both subjective and objective measurements.
Two types of groups are being created with two levels of independent variables. In parallel coordination mode ("parallel groups"), subjects will work through decision procedure individually, except agreeing on alternatives in advance, and final group selection through asynchronous on–line discussion. "Sequential" groups will works through one stage of the procedure at a time. Groups will need to reach agreement or aggregate individual results into a group one before moving onto the next stage of decision process. A facilitator will help monitor and collaborate the overall group process.

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