An Empirical Study Of Influences Of The Coordination Modes In Supporting Group Multiple-Criteria Decision-Making

Patrick P. Cao
Frada V. Burstein

School of Information Management and Systems
Monash University
Melbourne, Australia
Email: patrick.cao@sims.monash.edu.au
frada.burstein@sims.monash.edu.au

Abstract

Previous research has shown that different coordination methods influence the outcomes of group decision-making processes. The coordination mode comprises of procedures and aggregation methods applied in the group multiple criteria decision-making (MCDM) process. This paper studies the ***parallel*** *and* ***sequential*** *coordination modes. It then discusses an on-going research project, which aims to develop an Internet-based group decision support system (GDSS) and to further investigate the impacts of such a system on group MCDM process performed in parallel and sequential coordination modes. Features of the GDSS prototype and design of a follow-up laboratory experiment are described in this paper.*

Keywords

Group decision support, empirical study, coordination modes, research in progress

INTRODUCTION

Group decision-making plays an important role in organizations today. In addition, many of the decisions are made over alternatives by considering multiple, usually conflicting criteria. The complexity of group decision processes calls for the utilization of group decision support systems (GDSS) integrated with multiple criteria decision-making (MCDM) models. Considering multiple criteria in defining decision situation often helps to revile and resolve decision complexities by representing multiple characteristics of alternatives, which all the members of the group can agree on.

This paper presents a research project that aims to develop an Internet-based GDSS prototype built around a MCDM model, which provides support for 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 MCDM processes. In this paper, we define the *parallel* and *sequential* coordination modes in a group MCDM process, and briefly discuss the research method and design in our study. The GDSS prototype and a lab experiment design are also presented in this paper.

GROUP MULTIPLE CRITERIA DECISION-MAKING PROCESS

Group MCDM processes usually require a group of domain experts to formulate initially the problem, ie a set of alternatives and criteria to assess them. After the formulation stage, the appropriate MCDM models are used to evaluate alternatives agreed by all experts. In the final stage the most preferred one is selected as a group decision. Such a process may be supported by a GDSS built around one or a number of MCDM models. We study the group MCDM process as a decision-making process involving a group of people using one or more MCDM models as decision tools.

Successful group decision-making requires appropriate coordination processes for incorporating diverse individual views into an aggregated final decision. Suitable decision support tools may facilitate the processes and help the group improve the decision quality (Malone & Crowston, 1990). In an asynchronous and distributed environment, a key problem with the MCDM processes is the increased need for coordination of individual activities (Tindale, 1989). A coordination mode refers to a series of procedures, aggregation methods and algorithms, which incorporate the group and individual members activities and facilitate them to reach agreement of a high quality group decision.

In such an environment, each participant can sometime work individually and/or collaborate with the rest of the group at other time. For example, each participant may work through most of the phases in the decision-making process alone. He or she develops their own criteria, weighs those criteria on their own judgement, rates each alternative over the criteria, and evaluates overall alternatives with MCDM models. His or her final choice can then be aggregated with other participants' choices to form a group decision by using certain aggregation methods and algorithms. On the other hand, individual participant's preferences can be aggregated sequentially at several points over time. This means a set of agreed criteria, their weights, and rating of each alternative over each criterion may be sought before the evaluation of alternatives. This process requires that the group must reach certain consensus at one stage before moving on to the next. These two different processes result from two coordination modes, which are called *parallel* and *sequential* modes in this study. The detailed definitions of these two modes are given in Section 4.

A key difference of group decision-making from individual decision-making is the need for interaction between the group members during the decision-making process. This has led to researchers to focus on communication or information exchange issues during group meetings in the design of GDSS (Jacob and Pirkul, 1992). 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 (Tung, 1998). In an asynchronous and distributed setting, these two coordination modes may have significant influence on outcomes of group decision-making. Therefore, such research is needed 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.

PREVIOUS RESEARCH

Literature on MCDM seems to concentrate on methods for individual decision-makers with a large amount of autonomy (Lootsma, 1998). When MCDM process involves group of experts, the situation would be far more complex than in individual decision-making. Some issues come into play when dealing with the interaction of group members, as opposed to individual decision-making. Effective coordination of individual actions appears to be highly correlated with the quality and accuracy of the decision and performance in decision-making processes, which are the overriding concerns in getting the complicated task done.

One of the difficulties related to the coordination of group MCDM processes is the aggregation of individual opinions into a group one. Many studies have proposed methods for mathematically combining estimates made by individuals and evaluating their quality (Dougan, 1999). Because of the difficulty associated with applying mathematical algorithms to some decision tasks, researchers have often used other more practical techniques as methods of combining individual opinions in these situations. Hwang and Lin (1987) discussed many of these techniques such as Nominal Group Technique, Delphi, etc., grounded in the principles of utility theory, social choice theory, committee decision theory, theory of voting, game theory, and so on.

GDSS are, in essence, suites of tools, processes, and techniques designed to leverage the intellectual capital of groups and thereby increase their productivity (Briggs, Nunamaker, Reinig, Romano, and Sprague, 1998). Research on the coordination modes in distributed group support systems (DGSS) has recently focused on the issue of system restrictiveness, which refers to the degree to which a system limits its users decision-making processes to a subset of all possible processes (Silver, 1990). The other issue of research was the flexibility of coordination structure, and its influence on group decision outcomes and performances (DeSanctis, D'Onofrio, Sambqammurthy, & Poole, 1989; McLeod & Liker, 1992; Mennecke, Hoffer, & Wynne, 1992).

Research findings in this area are quite inconsistent. In studying synchronous group support system (GSS), Chidambaram and Jones (1993) reported that a GDSS with a high degree of system restrictiveness had negative impacts on group performance. An imposed coordination structure can be overly restrictive due to the limited bandwidth of the interaction medium. Research indicates that individuals come to the group with a relatively inflexible preference for a particular decision-making strategy (Putnam, 1982). It is also suggested that less restrictive coordination structures are more appropriate to support asynchronously interacting distributed groups (Kim, Hiltz, & Turoff, 1998). Therefore DGSS should be flexible enough to allow the individuals freedom to concentrate on aspects of the problem to which he or she can best contribute (Turoff, Hiltz, Bahgat, & Rana, 1993).

On the other hand, Dickson, Partridge, and Robinson's (1993) research indicated that GSS should be designed with some degree of restrictiveness. Too much freedom in group interaction decreases group cohesiveness. This, in turn, increases the decision cost either by generating a lower quality decision or taking more time to make a decision. Therefore, a coordination structure in DGSS should impose some restrictions on interaction to maintain a certain level of group cohesiveness. The varying outcomes may result from applying different degrees of system restrictiveness (Hiltz et al., In Press). 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 MCDM models to support the group decision-making processes. In our study, system restrictiveness is manipulated by applying certain procedures and aggregation methods (algorithms) to the GDSS process. By manipulating these procedures and aggregation methods in group MCDM, we try observe the impacts of different coordination modes on group decision outcomes and performance.

DEFINITION OF PARALLEL AND SEQUENTIAL COORDINATION MODES IN GROUP MCDM PROCESS

Turoff, Hiltz, Bahgat, and Rana (1993) adapted Thompson’s (1967) classification of organizational group activities into four coordination methods (modes) that group uses. They are:

- *Parallel*: each individual approaches the problem independently
- *Pooled*: same as parallel except a standard is utilized to formulate a group result such as group vote
- *Sequential*: all group members undertake the problem-solving phases in a sequential manner

- *Reciprocal*: changes made in one part of the problem can force other group members to reconsider other parts of the problem, such as in a case where consistency relations are imposed.

It should be noticed that the *parallel coordination* mods defined in our study covers the meaning of *parallel* and *pooled* structures classified in above study, while the *sequential coordination* mode conforms to both *sequential* and *reciprocal* structures, because the sequential modes defined in our study allows group members to go back to the previous decision process stage if needed.

Selection of MCDM Models

This specific kind of decision support systems (MCDSS) has evolved from single machine-based to having interactive structure integrated with artificial intelligence techniques (Jelassi, 1987). MCDM techniques constitute an important class of DSS with unique software requirements (Jelassi, Jarke, and Stohr, 1985). Selection of appropriate MCDM methods among huge amount of available ones in order to make the use of MCDSS more effectively long time attracts researchers attention. Hong and Vogel (1991) argued that a MCDM process does not necessarily correspond to a specific choice strategy of methods. At each stage of the decision process, decision-makers may evaluate the nature of the decision task and choose an appropriate method. So MCDSS must support execution of multiple models. This model can be used throughout the whole MCDM process.

For our prototype we have chosen the Simple Additive Weighting (SAW) Method (Yoon and Hwang, 1995) as a representative MCDM model. It is the best-known, and most widely used MCDM method. The restrictions for the application of this method can be quite easily satisfied. The SAW method assumes that criteria are preferentially independent. This means that the contribution of an individual criterion to the total (multi-criteria) score is independent of other criteria values. Therefore, the experts' preferences (or evaluations) regarding the value of one criterion is not influenced in any way by the values of the other criteria. In addition to the preference independence assumption, the SAW has a required characteristic for weights. That is, the SAW presumes that weights are proportional to the relative value of a unit change in each criterion's value function.

Within group decision-making using MCDM models, probably the most commonly used evaluation techniques are ranking, scoring, rating, and utility function, all of which express preferences in regard to a set of alternatives under consideration. The SAW method needs decision-makers to rate alternatives based on each criterion.

When applying SAW method to an individual decision-making process, the problem may be represented as finding an alternative A_I with the highest value of the linear utility function **V**:

$$V(A_i) = V_i = \sum_{j=1}^{n} w_j \, r_{ij}, \qquad i = 1, \ldots, m$$

Where $\mathbf{w_j}$ and $\mathbf{r_{ij}}$ are weight and the comparable scale of criteria **j**. They can be obtained by asking for experts' subjective preferences.

Group MCDM 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 MCDM process. Guided by these two coordination modes imposed to the decision-making process, group may reach a right decision at a right time.

Figure 1 represents the group MCDM processes coordinated by sequential and parallel modes. Before we describe detailed procedures with parallel and sequential coordination modes one premise needs to be agreed upon. We are aware that there may usually exist some conflicting views and opinions in the group. It would be easier for the group to agree on a set of possible alternatives beforehand, than to agree on the precise weights to assign to the various criteria, no matter what coordination mode is adopted. This procedure allows to avoid stumbling situation, when no agreement on initial set of alternatives between group participants is reached in advance, which later on may result in even grater differences between individual's preferred decisions. This satiation would go off so far that the aggregation would be too difficult to perform later on. It could be especially true when parallel mode is adopted.

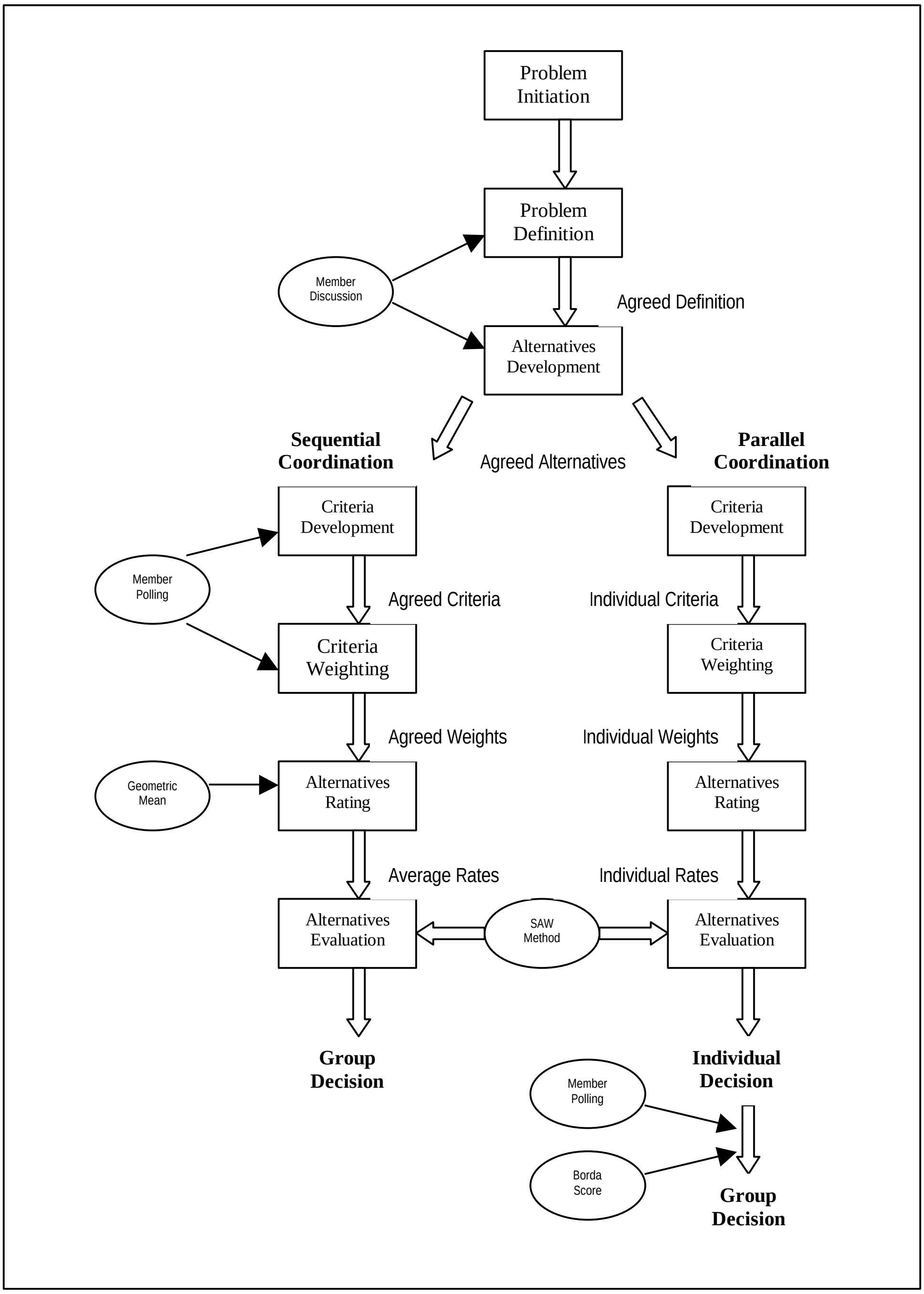

Figure 1: Group MCDM processes with two coordination modes Individual member develops his or her own criteria

In the next two sections we will define the *parallel* and *sequential* coordination modes respectively, in terms of their procedures and aggregation methods or algorithms. The main differences between the two are that aggregations are imposed more often in sequential than in parallel mode, and different aggregation method and algorithm are applied to these two processes. However, no matter what coordination modes are imposed, all of the processes start from having agreed alternatives.

- 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 and algorithm are described step by step as following:

1. The member determines the weight for each criterion;
2. The member rates each alternative based on each criterion;
3. The member gets his or her own preference of alternatives;
4. Each member's preference of alternatives is converted to a rank of alternatives;
5. *Borda* score is applied to determining a group rank for the alternatives. Borda score is a function that transforms an order of alternatives into a relative score, which indicates a collective order of alternatives (Hwang & Lin, 1987). For example, since **m** is the total number of alternatives, the first place alternative would receive a score of **m-1**, the second place, **m-2**, etc. Then the alternative with the highest Borda score, that is, the sum of all the group members Borda scores, would receive first place, the second place, etc.
6. Results of Borda score are then distributed to each group member for polling, in case that some of alternatives get the same Borda score, or group needs to confirm its agreement on the rank of alternatives.

- Sequential Coordination

Sequential coordination implies that consensus would be sought throughout some stages of decision-making process, from problem formulation to alternative evaluation. The consensus may be reached by applying aggregation methods and algorithm at any appropriate stage. Although more aggregations with sequential coordination bring about more restrictiveness to group members than in parallel coordination mode, group cohesiveness may be retained so that group decision quality may be acquired. A procedure with sequential coordination mode and corresponding aggregation methods and algorithm are:

1. Group needs to develop a set of criteria, which are agreed by each member as a collective criteria. These criteria may be acquired from members' discussion and polling;
2. Group needs to weigh the criteria at this stage. All members as should also agree on the set of weights as collective weights. Once again they can be sought through group discussion and polling;
3. Based on group's criteria, each group member can rate alternatives according to his or her preference, then the individuals' rating metrics will be converted to a group rating matrix by the geometric algorithm;
4. Once group's agreed criteria, weights and rating are ready, then the SAW method can be used to evaluate ratings for each alternative. The result is regarded as a group decision preference.

It needs to be noticed that this procedure is iterative rather than simply sequential. If the group is unsatisfied with the results at any stage, it may go back to any step and redo it.

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-making process in the asynchronous and distributed environment?"

Research Framework

The research adopts Nunamaker et al. (1993) general GDSS research model. Revised Version that conforms to our research design is presented in Figure 2. From this "input-process-output" system standpoint, *coordination mode* is an independent variable in our study. McGrath and Hollingshead (1994) 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.

Fjermestad (1998) also conceptualised two dynamic factors, intervening and adaptation along with the general context and outcome factors in his framework. Adaptation represents the interaction process of the group. Adaptation variables are controlled by the group on an individual or a collective basis. The changes in these variables act to influence the intervening variables. Model that grounds from the adaptive structuration theory developed by DeSanctis and Poole (1994), *coordination mode* is one of adaptation variables. This concludes that the effects of single elements (such as technology and task characteristics) do not determine group outcomes, but by a complex and continuous process in which those elements are appropriated by the group.

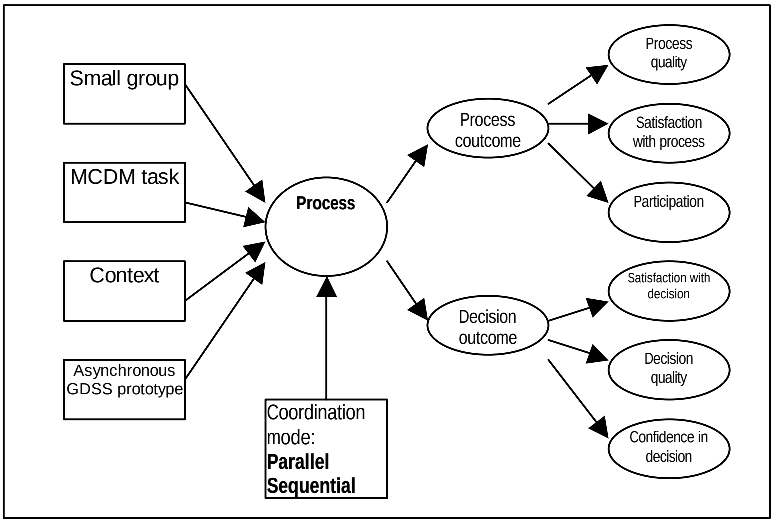

Figure 2: A Revised GDSS research framework adapted from (Nunamaker et al., 1993)

In order to answer the research question, we need to implement a GDSS, which provides appropriate procedures and tools to support the group MCDM 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 pre-defined MCDM process coordinated by the parallel and sequential modes. By observing the MCDM 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.

GDSS Prototype

- System Development Environments

The prototype has been developed in Lotus Notes R4.6 and Lotus Components V1.3 environments by using Notes @functions and @commands, and mainly, LotusScript, a fully object-oriented programming language. Then we are upgrading current version of the prototype onto Lotus Notes R5, a new environment that integrates design features of Notes workstation and its Internet server, Domino by using Domino Designer. This transformation will make the prototype an Internet-based system, which allows participants to proceed group decision-making procedure by using Web browsers (e.g., Microsoft Internet Explorer and Netscape) as interface and utilizes Notes database as an information repository at back-end.

- System Architecture

The system prototype is implemented with Lotus Domino as the middle tier of a three-tier architecture. The first tier comprises Web browser that handles the user input and display. The second and third tiers consist of the Domino server and a Notes discussion database respectively. Lotus Domino's role is to act as both server and application container. It acts as a server to the Web browser, where the participants can use MCDM models to evaluate alternatives, or interact with other group members through the decision-making process. It acts as an application 'container', holding the facilitation support component and a MCDM model base, which provides users with available MCDM models (currently containing SAW in the prototype). Notes discussion database stores correspondence information between group members, which records the process data and is available as memory for the use of future decision tasks.

- System Features

The prototype provides support for group MCDM process at three levels:

(a) Individual Activity Support

Each group member can input the criteria group by group in dialogue boxes prompted by the system. The grouped criteria are then stored in each participant's document, which can be accessed by the facilitator through the discussion database. User's input of criteria may be hierarchically displayed with a spreadsheet and modified if needed. Participants can also assess the alternatives by calling embedded SAW model and feeding it in with their own decision preference. The SAW model component accepts weights and subjective rating of the participant over each criterion. The value of each alternative then is computed automatically and presented onto the spreadsheet. A rank of alternatives based on participants' individual preferences is also displayed.

(b) Group Activity Support

Once all participants' preferences are available, an aggregation of these preferences then takes place as a starting point for generating group decision preference afterwards. This aggregation information is distributed to each group member for polling. The polling result is regarded as group's aggregated preference if every participant agrees, or another round of polling may be needed until a final consensus is reached.

(c) Facilitation Support

Facilitator plays an important role in the group decision-making process supported by the system prototype. He or she controls process agenda and monitors process status with a Notes workstation. The facilitator based upon a pre-defined agenda determines the progression from one segment of decision-making process to the next. The facilitation support component allows the facilitator to trace the participation status and progress of each group member.

LABORATORY EXPERIMENT DESIGN

The objective of the experiment is to examine how the use of *parallel* and *sequential coordination* modes with the Internet-based MCDM GDSS, 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*.

Subjects and Decision Task

The experimental subjects in the study will be undergraduate and postgraduate students enrolled in information systems courses. They will be trained in basic understanding of one of MCDM methods. The decision task for this study will be either a case study of solving MCDM problems selected from textbook, or familiar MCDM problem, that have been done previously by subjects (eg, buying a car). 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.

Independent Variable

Coordination mode is the independent variable in the study. It has two levels: *parallel* and *sequential*. Participants in the same subject group will either use parallel or sequential mode by making use of the prototype to work through MCDM process.

Dependent Variables and Hypotheses

According to McGrath and Hollingshead (1994), there are at least three standpoints from which one can assess the consequences of introduction of any given technology in work groups: *task performance effectiveness*, *group interaction*, *performance processes*, and *user reactions to the system and its results*. We have chosen to assess the prototype developed and coordination modes studied for enhancing the group MCDM processes depending upon the evaluation from all three of these standpoints. Also in this study, two classes of dependent variables, *process outcome* and *decision outcome*, are evaluated as the outcomes of group MCDM processes affected by two coordination modes.

- Process Outcome

George, et al (1990) defined the deterministic intervention of GDSS in the form of structured steps taken for problem solving activities from the point of view of users' satisfaction with process, and time to arrive to the final decision as *process outcomes.* In this study, *process outcome* is measured by *process quality*, *users' satisfaction with process*, and *participation*. We use the perceived *process quality* instead of time to decision as a subjective measure, because time factor is not as important in asynchronous environment as it is in synchronous environment as studied in previous research.

(a) Users' Satisfaction with Decision Process

Individuals' decision-making process may be less complex than when performed within a group setting. It would be possible that decision-makers choose alternative solutions individually by applying MCDM model and then got their preferences aggregated to form group decision more easily than when they are forced to work together through every step of the decision-making process. GDSS with a high degree of system restrictiveness leave less freedom for the group member to adaptively structure the system to its own preferable decision strategy. Sequential coordination has a higher degree of system restrictiveness than parallel mode. This prediction leads to the following hyposeses:

> *H1: Users' satisfaction with the process will be greater for groups working in parallell rather than sequential mode*

(b) Quality of Decision Process

The *quality of decision process* refers to the path taken by a group to arrive at the final decision. This variable is different from *quality of decision* in the sense that the latter represents the final decision itself, while the other represents the "journey". We predict that the process coordinated with parallel mode might be more efficient than the one with sequential mode, because the latter needs more frequent coordination at each stage of decision process. Therefore it might take more time and effort to reach consensus on a group decision. This prediction results in the hypothesis:

> *H2: Quality of the process will be better for groups working in parallel rather than sequential mode.*

(c) Participation

GDSS were found by many researchers to enhance level of participation among all members rather than allowing dominance by one or a few participants due to assurance of anonymity. However anonymity provided by most of synchronous GDSS may not affect participation in asynchronous and distributed setting, no matter what coordination mode is adopted.

> *H3: There will be no difference in level of participation for parallel and sequential modes*

- Decision Outcome

Reported impacts on decision outcome include better decision quality, as measured in terms of correctness, creativity or uniqueness of alternatives (Pervan, 1998). In this study, we include *users' confidence in decision outcome* and *satisfaction with final decision* as the other two factors that are relevant to the decision outcome. There are two hypotheses associated with these factors that this study attempts to address.

(a) Users' Confidence in Decision Outcome

Since the final decision comes from a more closely joint effort of the group throughout the process with sequential coordination mode than with the parallel one, it is reasonable to assume:

> *H4: Users' confidence in the final decision will be higher for groups working in sequential than parallel modes.*

(b) Quality of Final Decision

There is little consensus on whether a group decision-making process with higher system restrictiveness increases the quality of final decisions. The following hypothesis reflects our expectations about decision quality:

H5: There will be no difference in quality of the final decision between groups working in sequential and parallel modes.

(c) Users' Satisfaction with Decision Outcome

Users' satisfaction would be conformed to their confidence in decision outcome. Groups working in sequential mode might have an improved understanding of the task structure than those working in parallel. Thus we expect that:

H6: User satisfaction with decision outcome will be greater for groups working in sequential rather than parallel modes.

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 work 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.

REFERENCES

Briggs, R. O., Nunamaker, J. F. J., Reinig, B. A., Romano, N. C. J., & Sprague, R. R. J. (1998). Group Support Systems: A Cornucopia of Research Opportunities. In *Proceedings of the 31st Annual Hawaii International Conference on System Sciences*, (pp. 495-504). Hawaii: IEEE Computer Society.

Chidambaram, L., & Jones, B. (1993). Impact of Communication Medium and Computer Support on Group Perceptions and Performance: A Comparison of Face-to-Face and Dispersed Meetings. *MIS Quarterly*, *17*(4), 465-491.

DeSanctis, G., D'Onofrio, M., Sambqammurthy, V.&Poole, M. S. (1989). Comprehensiveness and Restrictiveness in Group Decision Heuristics: Effects of Computer Support on Consensus Decision Making. In *Proceedings of the tenth International Conference on Information Systems*, (131-140). Boston, MA: Association for Computing Machinery.

DeSanctis, G., & Poole, M. S. (1994). Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science*, *5*(2), 121-147.

Dickson, G., Partridge, J. L., & Robinson, L. (1993). Exploring Modes of Facilitative Support for GDSS Technology. *MIS Quarterly*, *17*(2), 173-194.

Dougan, W. L. (1999). Extending Mathematical Aggregation Strategies to Multiparameter Group Decisions. *Small Group Research, 30*(2), 188-208.

Fjermestad, J. (1998). An Integrated Framework for Group Support Systems. *Journal of Organizational Computing and Electronic Commerce*, *8*(2), 83-107.

George, J., Easton, G. K., Nunamaker, J., & Northcraft, G. B. (1990). A Study of Collaborative Group work withand without Computer-based Support. *Information Systems Research*, *1*(4), 394-415.

Hiltz, S. R., Dufner, D., Fjermestad, J., Kim, Y., Ocker, R., Rana, A., & Turoff, M. (In Press). Distributed Group Support Systems: Theory Development and Experimentation. In G. M. Olsen, J. B. Smith, & T. W. Malone (Eds.), *Coordination Theory and Collaboration Technology* . Hillsdale NJ: Lawrence Erlbaum Associates.

Hong, I. B., & Vogel, D. R. (1991). Data and Model Management in a Generalized MCDM-DSS. *Decision Sciences, 22*(1), 1-25.

Hwang, C.-L., & Lin, M.-J. (1987). *Group Decision Making under Multiple Criteria: Methods and Applications*. (Vol. 281). Heidelberg, Germany: Springer-Verlag.

Jacob, V. S., & Pirkul, H. (1992). A Framework for Supporting Distributed Group Decision-Making. *Decision Support Systems, 8*(1), 17-28.

Jelassi, M. T. (1987). MCDM: From 'Stand-Alone' Methods to Integrated and Intelligent DSS. In Y. Sawaragi, K. Inoue, & H. Nakayama (Eds.), *Toward Interactive and Intelligent Decision Support Systems* (Vol. 2, pp. 90-99). Heidelberg, Germany: Springer-Verlag.

Jelassi, M. T., Jarke, M., & Stohr, E. A. (1985). Designing a Generalized Multiple Criteria Decision Support System. *Journal of Management Information Systems, 1*(4), 26-43.

Kim, Y., Hiltz, S., & Turoff, M. (1998). Coordination Structure and System Restrictiveness in Distributed Group Support Systems: An Experiment on Coordination Mode and Leadership. In *Proceedings of the 31st Annual HICSS*, (pp.145-153). Hawaii: IEEE Computer Society.

Lootsma, F. A. (1998). Prospects for MCDA in Groups. *Journal of Multi-Criteria Decision Analysis, 7*(3),121-2.

Malone, T. W., & Crowston, K. (1990). What Is Coordination Theory and How Can It Help Decision Cooperative Work Systems? In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work*, (pp. 357-370). Los Angeles: The Association for Computer Machinery.

McGrath, J. E., & Hollingshead, A. B. (1994). *Groups Interacting with Technology: Ideas, Evidence, Issues, and an Agenda*. (Vol. 194) Thousand Oaks, CA: Sage Publications.

McLeod, P. L.&Liker, J.(1992). Electronic Meeting Systems: Evidence from a Low Structure Environment. *Information Systems Research, 3*(3), 195-223.

Mennecke, B. E., Hoffer, H. A., & Wynne, B. E. (1992). The Implications of Group Development and History for Group Support System Theory and Practice. *Small Group Research, 23*(4), 524-572.

Nunamaker, J. F., Dennis, A. R., Valacich, J. S., Vogel, D. R., & George, J. F. (1993). Group Support Systems Research: Experience from the Lab and Field. In L. M. Jessup & J. S. Valacich (Eds.), *Group Support Systems: New Perspective* (pp. 125-145): Macmillan Publishing Company.

Pervan, G.P. (1998). A Review of Research of Group Support Systems: Leaders, Approaches and Directions. *Decision Support Systems, 23(2)*, 149-159.

Putnam, L. L. (1982). Procedural Messages and Small Groups' work Climates: A Lag Sequential Analysis. *Communication Yearbook, 5*, 331-350.

Silver, M. S. (1990). Decision Support Systems: Directed and Nondirected Change. *ISR, 1*(1), 47-70.

Thompson, J. D. (1967). *Organizations in Action*. New York: McGraw-Hill.

Tindale, R. S. (1989). Group vs. Individual Information Processing: The Effects of Outcome Feedback on Decision Making. *Organizational Behaviour and Human Decison Process, 44*, 454-473.

Tung, Y. A. (1998). Time Complexity and Consistency Issues in Using the AHP for Making Group Decisions. *Journal of Multi-Criteria Decision Analysis, 7*(3), 144-154.

Turoff, M., Hiltz, S. R., Bahgat, A.&Rana, A. (1993). Distributed Group Support Systems. *MISQ, 17(4)*, 399-417.

Yoon, K. P., & Hwang, C.-L. (1995). *Multicriteria Attribute Decision Making: An Introduction*. (Vol. 104). Thousand Oaks, CA: Sage Publications.

COPYRIGHT