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Web Support System for Group Collaborative Decisions

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Abstract: In this research, we present a Group Decision Support System (GDSS) based on web technology, which can be used in asynchronous mode from group members. It supports small collaborative groups in classification decisions, implementing a supervised multicriteria methodology. A facilitator, who defines necessary parameters and initiates the procedure, coordinates the entire operation. Next, members evaluate the proposed parameter set and express their preferences in numeric format. Aggregation of individuals' preferences is executed at the parameter level by utilization of OWA operator and a group parameter set is produced which is used as input for the classification algorithm. A multicriteria classification algorithm is used for the classification of actions (people, projects etc.). Finally, group members evaluate results and consensus as well as satisfaction indexes are calculated. In case of low acceptance level, parameters are redefined and aggregation phase is repeated. The system has been utilized effectively to solve group classification problems in business environment. The overall architecture as well the methodology is presented, along with a sample application. Empirical findings from GDSS application and the methodology provide evidence that it is a valid approach for similar decision problems in numerous business environments, including production, human resources and operations.

Key words: Group decision support, multicriteria analysis, OWA operator

INTRODUCTION

Group decision making has become an essential component of strategic planning and operations for the majority of today's organizations and enterprises. Since complexity of business environment requires sufficient knowledge from a wide range of domains, contribution of a team of experts with key skills is the only way to achieve efficiency in decisions. In order to support groups' needs, researchers work on developing tools and methodologies, ranging from collaboration technologies to decision support systems. However, group decisions are quite more complex compared to single decision making, since a number of contradicting factors are involved such as individuals' personal opinions, goals and stakes resulting in a social procedure, where negotiation and strategy plays a critical role. Group decision making in real business environments raises also some issues (Karacapilidis and Gordon, 1995) such as conflicting individual goals, not efficient knowledge, validity of information and individuals' motivation.

Research in decision support systems targets towards supplying decision makers with appropriate tools to assist them in optimizing their decisions. Group decision support has received significant attention due to its application to various business domains. Since a decision support system has to reflect decision makers' preferences or decision model, building an appropriate Group Decision Support System (GDSS) is not a straightforward process. Moreover, a number of issues such as individuals' preference modelling, negotiation protocols and coordination, have to be considered. Collaborative and negotiation methodologies and tools have been developed in order to support groups, depending on whether group members share a common goal or support individual goals. Technologies acquired for developing a GDSS tend to follow advances in Information Technology, resulting in recent advanced systems. Incorporation of web technologies nowadays, for example, can support collaboration features, which could not be implemented in the very early GDSSs.

Focusing on integration of multicriteria analysis within group decisions, we performed a detailed survey of relevant approaches and especially on GDSSs. In Table 1 we present an overview list of research works, which demonstrate integration of multicriteria analysis within group decision environment and utilization of multicriteria analysis in GDSSs. An extensive review of multicriteria

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Table 1: Group decision support system incorporating multicriteria methodologies

Multicriteria methodology	References
Multicriteria mathematical programming	Kersten (1985)
Utility theory	Jarke *et al.* (1987)
AHP, ELECTRE	Bui (1987)
Satisfying framework	Lewandowski (1989)
Alternative Evaluator tool	Nunamaker *et al.* (1991)
AHP	Carlsson *et al.* (1992)
Multicriteria mathematical programming	Iz (1992)
SMART	Quaddus *et al.* (1992)
Utility theory	Vetchera (1994)
ELECTRE και PROMETHEE	Colson and Mareschal (1994)
PROMETHEE	Espinasse and Pauner (1995)
AHP, Utility theory	Csaki *et al.* (1995)
AHP	Noori (1995)
Utility theory	Rangaswamy and Shell (1997)
AHP, ELECTRE, PROMETHEE-2, Compromise programming	Raju and Kumar (1998)
Multicriteria math. programming	Teckle *et al.* (1998)
Multicriteria math. programming	Lu *et al.* (1999)
Utility theory (MAUT)	Kim and Choi (2001)
Fuzzy integrals	Deer *et al.* (2001)
AHP	Vihakapirom (2002)
AHP, PROMETHEE, MAUT	Geldermann *et al.* (2003)
AHP, PROMETHEE II	Genova *et al.* (2004)
Utility theory	Pongpeng and Liston (2003)
AHP, ELECTRE III, SMART	Cil *et al.* (2005)

analysis integration within GDSSs is presented by Matsatsinis and Samaras (2001). However, from analysis of existing approaches, we identify that the majority of the approaches provides support to choice decisions and web technology utilization is relative low. In addition, there is lack of support for group classification problems, although such problems occur within group settings, in production and financial domains.

Considering the above, we argue that in the case of group classification problems, multicriteria analysis provides a structured way for problem formulation and guides members to understand all the requirements effectively and express their preferences reflecting their decision model. To support this, we developed a structured methodology for group classification decisions which is based on multicriteria analysis and a GDSS, which implements it. In brief, the objective is the assignment of a set of actions (people, numbers etc.) to a number of predefined categories, according to their score on a set of evaluation criteria, by a group of decision makers. Initially group facilitator proposes a set of parameters. Group members evaluate the proposed parameter set and express their preferences in numeric or linguistic format. OWA operator (Yager 1988, 1993) aggregates individual preferences and a group parameter set is produced which is used as input for a supervised multicriteria classification algorithm. Finally, group members evaluate results and consensus as well as satisfaction metrics are calculated. In case of low level of acceptance, group members redefine problem parameters and aggregation phase is repeated.

The overall architecture of the GDSS was based on web technology in order to be easily integrated within existing business infrastructure. We followed a layered approach, implementing concepts from Service Oriented Architecture (SOA), aiming to provide a subset of the functionality of the GDSS in terms of Web Services. The GDSS has been applied in business environment and evaluated by decision makers, operating within the environment of a Greek bank, supporting financial decisions. Empirical findings from GDSS application have been analyzed and enhancements have already been incorporated in order to improve existing functionality and provide additional features. Regarding the overall methodology, findings provide evidence that it is a valid approach for similar decision problems in numerous business environments.

In this research we, present the methodology and the GDSS, as well as an illustrative example of a real world application along with empirical findings on GDSS evaluation. Following the introduction in group decisions and multicriteria analysis we present the group decision multicriteria methodology as well as the architecture of the developed GDSS mentioning key features of the system. Next we provide data from methodology and GDSS application in order to illustrate its usage and applicability and conclude with discussion on evaluation of the system as well as findings from its operation in real business environment.

MATERIALS AND METHODS

In general, multicriteria analysis can be incorporated as a method to model preferences and facilitate decision making within a group of decision makers. Modeling group decisions within multicriteria setting can be formulated under two major directions. In the first approach, individual multicriteria models are developed, which capture individuals' preferences. Each group member formulates a multicriteria problem defining the parameters according to her preferences and solves the problem getting an individual solution set. Next, separate solutions are aggregated providing the group solution. In the second approach, one multicriteria model is developed for the entire team. Each group member provides a set of parameters, which are aggregated by appropriate operators, providing finally a group parameter set. Upon this set the muticriteria method is applied and the solution expresses the group preference. Each approach poses both positive and negative aspects depending on the aggregation operation, which is followed. Our approach follows the second direction, calculating a set of group parameters, which is used as input for the classification algorithm. OWA aggregation operator executes aggregation of individual preferences. In this section we present the methodology as well as the overall architecture of the developed GDSS.

Initially, we present the multicriteria algorithm for the classification. The algorithm is based on the concept of inclusion/exclusion of an action with respect to a category. In general, the classification problem that we want to solve is defined as: Having a set of actions (e.g., projects, people, numbers etc.), a set of non-ordered categories which are defined by their least typical representative (entrance threshold) and a set of evaluation criteria, assign actions to categories with respect to their score on the evaluation criteria and the inclusion/exclusion concept.

Inclusion/exclusion from a category is determined by evaluating the fuzzy inclusion degree of the action for the specific category, following the concordance/non-discordance concepts as used in ELECTRE III method (Roy, 1991). Categories are defined by an entrance threshold, which can be considered as the least typical representative action that satisfies the inclusion requirements. The objective of the algorithm is to classify actions to categories in a way to consider inclusion/exclusion concept.

Fuzzy inclusion degree: The inclusion/exclusion concept defines at what degree an action can be included in a category or excluded from it. In order to utilize this concept for classification of actions, we define the fuzzy inclusion relation. Fuzzy inclusion relation P(a, b) is defined as a binary relation between an action a_i and a category threshold b^h. According to the concept of inclusion/exclusion and considering category thresholds, an action a_i is preferred over a threshold b^h (and can be thus included in the category C^h) if there is a majority of criteria supporting preference of action a_i over threshold b^h and there is no strong opposition to this. In order to evaluate the relation P(a, b) we utilize concordance/non-discordance principle, defining appropriate indexes as follows:

- A criterion is said to be concordant if it expresses agreement about classification of action a_i to a class b^h. For the evaluation of concordance per criterion, we define the partial inclusion index for action a_i and criterion g_j as C_j (a, b^h). In order to overcome imprecision in definition of data, we define two discrimination thresholds $q(g_j)$ and $p(g_j)$ for each criterion, resulting in three areas of values as follows:

$$C_j(a_i,b^h)=\begin{cases}0, & g_j(a_i)\le g_j(b^h)+q(g_j)\\ \dfrac{g_j(a_i)-g_j(b^h)-q(g_j)}{p(g_j)-q(g_j)}\in[0,1], & g_j(b^h)+q(g_j)\le g_j(a_i)\le g_j(b^h)+p(g_j)\\ 1, & g_j(a_i)\ge g_j(b^h)+p(g_j)\end{cases} \quad (1)$$

- For the evaluation of concordance degree for all criteria, we define the comprehensive inclusion index for action a_i as:

$$C(a_i,b^h)=\sum_{j=1}^{m} w_j * C_j(a_i,b^h) \quad (2)$$

Where, w_j is the importance weight of criterion g_j.

- In some cases a criterion can express negative judgment about classification of action a_i to a class C^h. More specifically, a criterion g_j can express a significant opposition to action's a_i preference (or inclusion) over threshold b^h. In this case the criterion is discordant with the inclusion relation between action a_i and threshold b^h. We define a discordance index D_j (a, b^h) for every criterion, in order to measure the discordance degree. To handle imprecision, we define a veto threshold $v(g_j)$ for each criterion as the minimum value which is incompatible with the assertion that the criterion is discordant with the inclusion relation, resulting in three areas of values as follows:

$$D_j(a_i,b^h)=\begin{cases}0, & g_j(a_i)\le g_j(b^h)+p(g_j)\\ \dfrac{g_j(a_i)-g_j(b^h)-p(g_j)}{v(g_j)-p(g_j)}\in[0,1], & g_j(b^h)+p(g_j)\le g_j(a_i)\le g_j(b^h)+v(g_j)\\ 1, & g_j(a_i)\ge g_j(b^h)+v(g_j)\end{cases} \quad (3)$$

- Utilizing the concordance/non-discordance principles we define the comprehensive fuzzy inclusion relation aggregating the inclusion relations (Eq. 2) weakened by discordance (Eq. 3) as:

$$P(a_i, b^h) = C(a_i, b^h) * \prod_{j=1}^{m} \left(\frac{1 - D_j(a_i, b^h)}{1 - C(a_i, b^h)}\right) \quad (4)$$

- Finally, we define the fuzzy inclusion degree as:

$$\gamma(a_i, C^h) = P(a_i, b^h) \quad (5)$$

Classification methodology: The methodology for solving group classification problems using the fuzzy inclusion degree as defined above is comprised of the following phases:

Problem definition: In this phase Facilitator initiates the decision problem, defining all appropriate parameters. In details:

- **Basic parameters:** Initially, facilitator defines a number of basic parameters, related to classification problem such as the number of group members, the number of categories, the number of criteria and to results assessment such as the consensus, satisfaction and acceptance levels. These levels define minimum required levels for the group decision. In case they are not satisfied, a second round is executed with modification of individual preferences.
- **Members:** Facilitator defines group members $M = \{m_1, m_2, ..., m_n\}$ and all necessary contact details.
- **Categories:** Facilitator defines the set of categories $\Omega = \{C^1, C^2, ..., C^h\}$ for the classification of alternatives.
- **Evaluation criteria:** Facilitator defines the set of evaluation criteria $F = \{g_1, g_2, ..., g_n\}$ according to problem requirements.
- **Criteria weights:** Facilitator defines the criteria weights.
- **Alternatives:** Facilitator defines the set of alternatives $A = \{a_1, a_2, ..., a_m\}$ for classification and defines their performance on the evaluation criteria $\forall a, g(a) = (g_1, (a), g_2(a), ..., g_n(a))$.
- **Entrance thresholds:** Facilitator defines appropriate entrance thresholds b^h for each category $\Omega = \{C^1, C^2, ..., C^h\}$ and defines their scores to evaluation criteria $g_j(b^h)$.
- For each threshold facilitator defines preference, indifference and veto thresholds.
- **Training set:** Facilitator defines a subset of alternatives as training set, in order to evaluate parameters' accuracy.

After the initiation of the parameters, facilitator communicates through the GDSS with group members informing them about the problem and asking them to submit their preferences.

Aggregation of individuals' parameter sets: In this phase group members express their preferences on the proposed parameter set. Member preferences are expressed or converted in numeric values. For the aggregation of values we utilize the OWA Operator (Yager 1988, 1993). Aggregation of member preferences is executed for the following parameters.

- **Criteria:** Group members express their acceptance on each proposed criterion in a five point scale and their preferred weight in numeric value.
- **Alternatives:** Group members express their acceptance on alternatives' performance or submit their preference in numeric value.
- **Categories:** Group members express their acceptance on each category definition and submit their preferences on category thresholds in numeric value.

For the aggregation of values we execute the following procedure based on OWA operator (Yager, 1988, 1993). If p_i is the value of a parameter defined by ith decision maker, then the aggregated group value c_i of the parameter is defined as:

$$\phi_w(p_1, ..., p_n) = \sum_{i=1}^{n} w_i \cdot p_{\sigma(i)}$$

Where, $\sigma: \{1, ..., n\} \rightarrow \{1, ..., n\}$ is a permutation such that, $p_{\sigma(i)} \geq p_{\sigma(i+1)}$ $\forall I = 1, ...n-1$ $p_{\sigma(i)}$ is the ith highest value of $\{p_1,...,p_n\}$ set. Weights $W = (w_1, ..., w_n)$ with $w_i \in [0,1]$, $\sum_{i=1}^{n} w_i = 1$ are given by the following expression $w_i = Q(i/n)-Q((i-1)/n)$, $I = 1, ..., n$, where, non-decreasing proportional quantifier's Q membership function is given by the following expression

$$Q(r) = \begin{cases} 0, & \text{if } r < a \\ \dfrac{(r-a)}{b-a}, & \text{if } a \leq r \leq b \\ 1, & \text{if } r > b \end{cases}$$

$a, b, r \in [0,1]$. For our system we select the following values which represent the concept of fuzzy majority $(a, b) = (0.3, 0.8)$.

Next, facilitator proceeds with validation of members' input and aggregates the values. Parameters with low acceptance level are marked and are subject to review if final results are not acceptable by group members.

Classification algorithm application: After the problem formulation and parameter aggregation, the following steps are followed for the set of actions to be classified using the group parameter set as input:

- For each action a_i we calculate the fuzzy partial inclusion relations (Eq. 1) over all thresholds b^h and categories C^h.
- For each action a_i we calculate comprehensive inclusion relations (Eq. 2) and the discordance indexes (Eq. 3) over all thresholds b^h and categories C^h.
- For each action a_i we calculate fuzzy inclusion degree for every category C^h (Eq. 4).
- We Assign action a_i to the category for which the fuzzy inclusion degree is the maximum $a_i \in C^h \Leftrightarrow \gamma(a_i, C^h) = \max\{\gamma(a_i, C^h)/i\in[1, h]\}$.

Classification algorithm is initially applied to the training set, as it has been defined by group members. Classification is executed by facilitator and group members are informed to assess the results. Then, each member expresses her preference on the results in a five point scale and in case of low acceptance level facilitator executes a second round of parameter definition from members in order to calibrate the model. When training set classification is acceptable, facilitator proceeds with classification of entire set of alternatives. In case of low acceptance level after the second round, facilitator terminates the process in order to revise the problem with stakeholders. Classification algorithm is finally applied to the entire set by facilitator and group members are informed to assess the results.

Results assessment: Group members assess the results expressing their preference in a five point scale. In case of low acceptance level facilitator reruns the model, requesting modifications from members.

GDSS overview: For the application of the above methodology, a GDSS was developed. The design of the GDSS was based on the following requirements:

- **Collaboration:** GDSS should promote collaboration between group members by appropriate functions. Group members for similar decision problems, can be selected ad hoc without any prior collaboration. GDSS should thus promote to members the feeling of a common goal minimizing thus individual goals.
- **Communication:** Since business operations may span over several locations, members can be located separately. Communication thus between facilitator and group members should be efficient enough in order to provide results in a timely way. GDSS should thus provide appropriate communication tools.
- **Anonymity:** Although anonymity poses some negative issues, it encourages members express their preferences without restrictions or external influence. For this reason, the GDSS should support anonymity at presentation level.
- **Asynchronous operation:** Different time zones and locations of today's business operations require asynchronous operation and decision making. GDSS should thus provide asynchronous operation efficiently.

Considering the above requirements, a layered approach which can be easily deployed in an existing business web environment was selected for the GDSS architecture (Fig. 1). Regarding the technology utilized, GDSS modules have been entirely developed in Java language using JCharts library for chart preparation. Apache web server is used to host the entire site and Tomcat is used as servlet container. Tomcat Axis is used for the deployment of web services. Data layer has been implemented in MySQL database, but can be hosted in any relational database.

GDSS architecture: GDSS is comprised of the Data, Application and Web layers:

- Application layer hosts all the functional modules which implement the methodology. The GDSS has been developed in Java language and includes the following major functional modules:

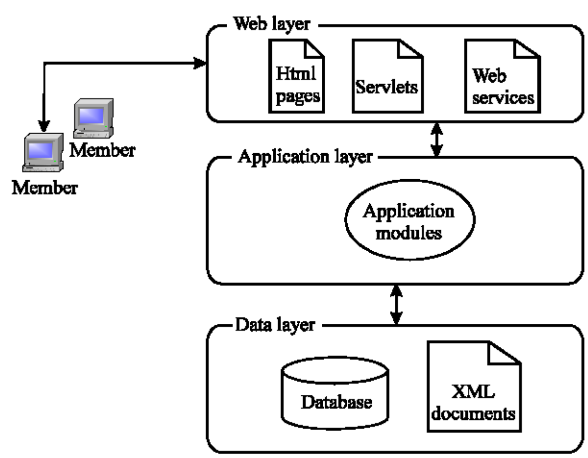

Fig. 1: Overall GDSS architecture

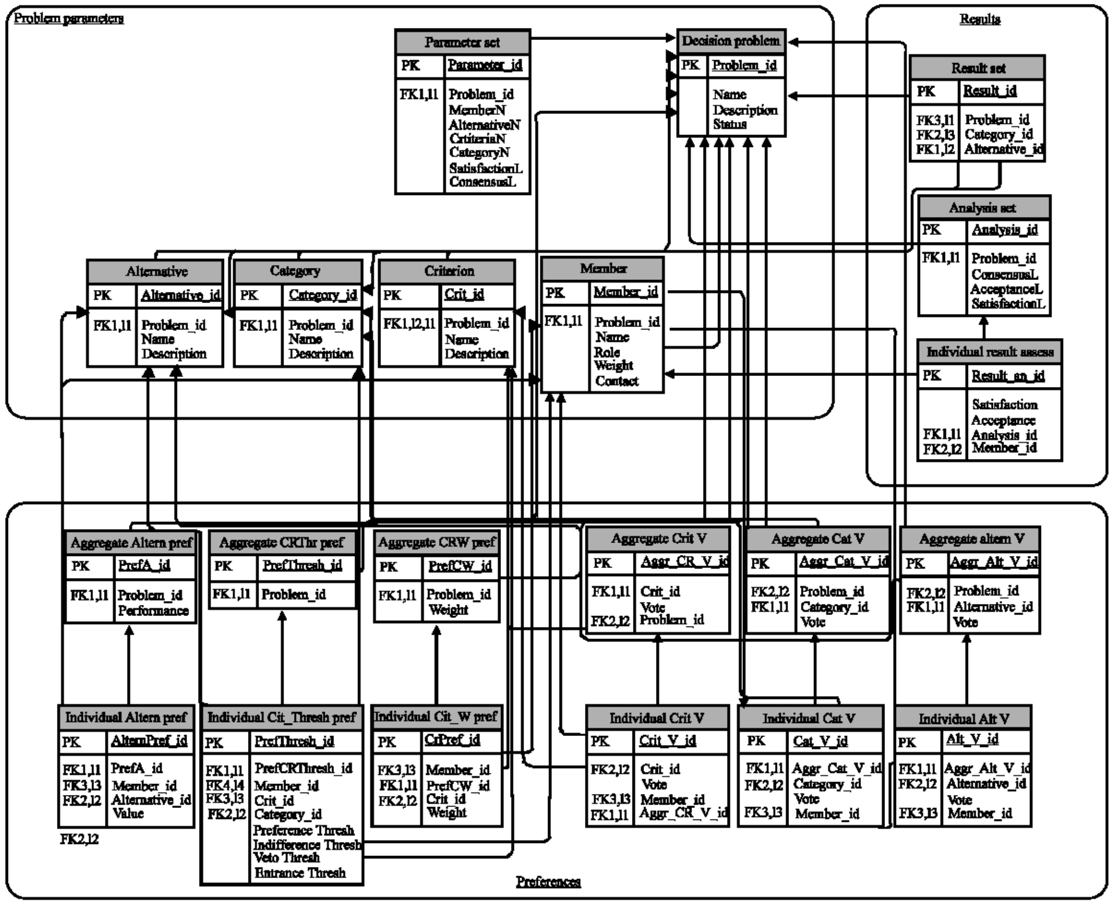

Fig. 2: GDSS Conceptual data model

- **Group facilitation module:** It is the core module of GDSS, which is responsible for the coordination of group actions.
- **Communication module:** This module implements all the necessary functionality, which is required for the communication between group members and Facilitator.
- **Multicriteria algorithm module:** This module implements the NeXClass multicriteria classification algorithm.
- **Aggregation module:** This module implements all the aggregation processes following the methodology. OWA aggregation previously presented is applied on individual preferences.
- **Presentation module:** This module is responsible for the presentation formatting, in both simple numeric and graphical formats. Utilization of graphs for result visualization, increases familiarization and understanding from group members. For the development of graphs JChart library has been utilized.

Data layer, stores all the necessary data for decision problems (Fig. 2). It is one of the core components of GDSS architecture and is responsible for storing all the necessary data for each classification problem. Since the orientation of GDSS is to operate into business environment, the data model was designed to meet relevant demands. It can store problem parameters from multiple simultaneous decision problems and can handle any combination of group members and parameters without conflicts. It can also store previous problems or demonstration ones for educational purposes, with specific consideration to privacy issues. In order to meet the above needs, we have implemented a relational model distinguishing three major virtual groups of entities: Problem parameters, Preferences and Results. Each one consists of a number of tables which along with the relations satisfy the needs for the DSS.

- Problem parameters group stores all necessary data related to a group problem. Parameters include all necessary data for a decision problem, such as information on criteria, categories, alternatives and members.

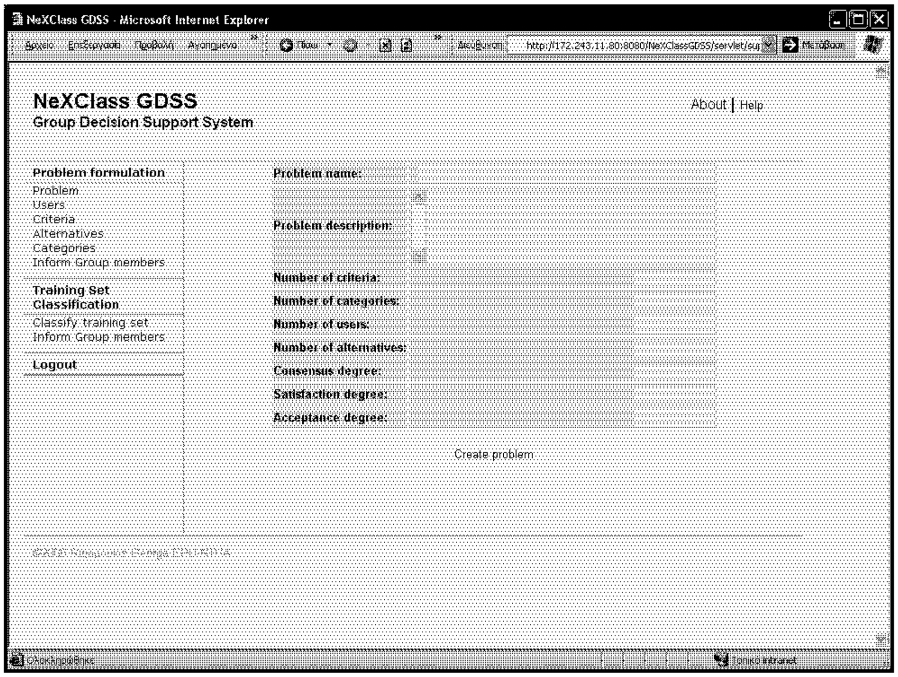

Fig. 3: Facilitator's mode for problem initiation

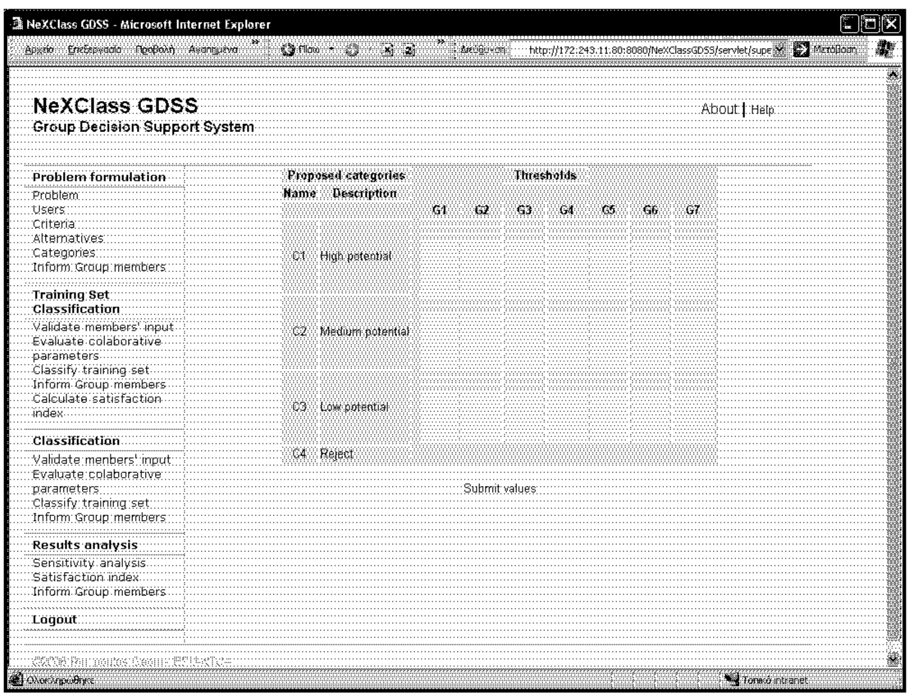

Fig. 4: Facilitator's mode for category thresholds definition

- Preferences group stores all the data representing group members' preferences. Preferences group is separated into two sub groups, which store individuals' and aggregated preferences accordingly. Aggregated preferences data is the input for the multicriteria classification algorithm.

- Results group stores all the data related to the results of the problem.

The model can reside in any relational database available at business environment. In addition, there is the option to import data in the form of XML documents for decision problems with large number of alternatives, when the data are already present into another system.

Web layer, provides all the user interface functionality. User interface has been designed in order to guide users through the steps of the methodology and has been implemented using web technology. Servlets and html pages offer GDSS functionality to group members in a user friendly way. In addition, an XML interface has been developed for importing data for large scale problems which are already stored in existing systems. Finally, a subset of GDSS functionality can be provided as a web service.

GDSS functionality: GDSS is accessed through a login page, where users have to provide appropriate passwords. The system recognizes two roles: Facilitator and Member. Facilitator works on a full functional mode of the system, while group members work on a mode presenting a subset of functionality. Facilitator initiates a new problem (Fig. 3) or selects to process an existing one. For a new problem, he defines the proposed parameters and informs group members (Fig. 4). For an existing problem, he can validate members' input and proceed to aggregation of preferences and classification of the training set.

After logging to the GDSS, members can select a problem and insert their preferences upon the proposed parameter set. Several graphs provide visualizations over the numeric parameters helping members understanding in problem parameters.

After validation of members' input and aggregation of preferences, facilitator executes the classification algorithm using the appropriate functions from his menu and informs members for the classification results for the final assessment phase.

RESULTS AND DISCUSSION

Below we present the application of the methodology and the GDSS to a real world classification problem within the environment of a bank. One of the decision problems that the bank faces is appropriate location choice for ATM installation. Due to the cost of a failed installation, it is critical to select a place with potential high volume of transactions. At present a number of factors are considered from bank's decision makers and potential sites are evaluated on a heuristic based approach. This practice is not effective, since a percentage of the installed ATMs are not viable, since installation and operating costs are very high. Relocation of such an ATM imposes an extra cost and is not always successful. For this reason, bank needs a more structured way to identify sites for ATM installation with high potential.

In order to support bank's decisions, we applied our methodology and GDSS and formulated a group classification problem. for the classification of locations to appropriate non-ordered categories. Following a brainstorming technique, stakeholders from bank's divisions which are involved in the ATM installation and operation as well as business development defined an initial set of parameters and the scope of the decision problem. They also assigned the supervision and operation of the entire decision procedure as well as the group coordination to a facilitator.

Facilitator initiated a problem in the GDSS and defined the initial set of parameters, informing group members. Members were selected from Marketing, Customer Service, IT, Operations, Electronic Banking Divisions. Totally, nine members formed the group and everyone could access GDSS through the bank's intranet.

Initially, four classification categories were proposed by bank's experts and facilitator, depicting the relevant potential of a location for an ATM installation (Table 2). Aggregation of members' opinion on these resulted to rejection of category C3 since group acceptance level was below the limit defined by facilitator and thus it was excluded from the problem.

Next a set of evaluation criteria was defined (Table 3) following bank's analyses as well as relevant approaches. Criteria quantification was based on expert's opinion reflecting bank's preferences. Aggregation of members' opinion on these resulted to rejection of criteria G4 and G9 since group acceptance level was below the limit defined by facilitator.

Based on the above, the following final set of seven criteria and three categories was defined (Table 4).

Next, group members expressed their preference on criteria weights, following the proposed weight from facilitator (Fig. 5). In Table 5 we depict the aggregated criteria weights as well as the individual weights of group members (M1,…,M9).

In addition to criteria, members defined thresholds for each category. In Table 6 we depict the aggregated criteria weights as well as the individual weights of group members (M1,…,M9).

GDSS allows members to view their proposed values in graphic way, helping them to express their preference (Fig. 6) more efficiently.

Table 2: Defined categories for ATM location classification

Category	Description	Group acceptance level	Category acceptance
C1	Sites with high potential and high cost	High	Accepted
C2	Sites with medium potential and low cost	High	Accepted
C3	Sites with low potential and low cost	Low	Rejected
C4	Sites with medium potential and medium cost	High	Accepted

Table 3: Defined criteria for ATM location evaluation

Criterion	Definition	Scale	Group acceptance level	Criterion acceptance
G1	Ease of access to ATM location	1-100	High	Accepted
G2	Competition from other bank's ATMs	1-100	High	Accepted
G3	Visibility of ATM	1-100	Medium	Accepted
G4	ATM Position in store	1-100	Low	Rejected
G5	Store position in area	1-100		Accepted
G6	Competition from same bank's ATMs	1-100	High	Accepted
G7	Merchant activity within the location area	1-100	High	Accepted
G8	Population density within the location area	1-100	Medium	Accepted
G9	ATM distance from high population density areas	1-100	Low	Rejected

Table 4: Final group set of categories and criteria

Category	Description	Criterion	Description
C1	Sites with high potential and high cost	G1	Ease of access to ATM location
C2	Sites with medium potential and low cost	G2	Visibility of ATM
C3	Sites with medium potential and medium cost	G3	Store position in area
		G4	Competition from other bank's ATMs
		G5	Competition from same bank's ATMs
		G6	Merchant activity within the location area
		G7	Population density within the location area

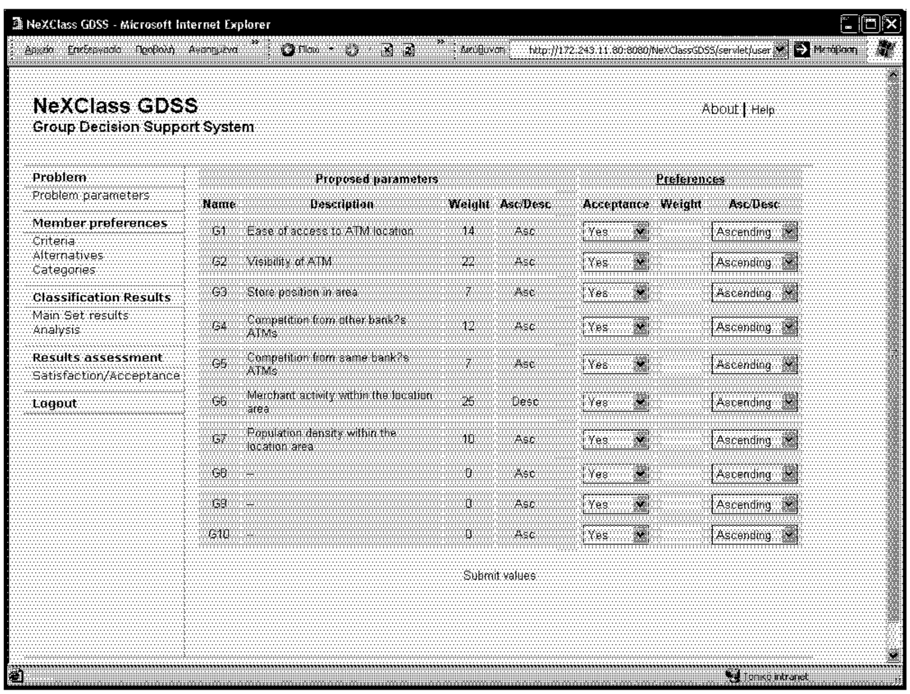

Fig. 5: Member's mode for parameter definition on criteria

We selected a small number of locations as a reference set of alternatives for classification, which were evaluated according to the seven criteria. Aggregated scores of the alternatives are depicted below (Table 7), where we present the group values. Appropriate graphs depict the scores with respect to categories' thresholds (Fig. 7).

Finally, the classification algorithm was executed by facilitator and classification results were derived. Results are depicted in Table 8, in comparison to group

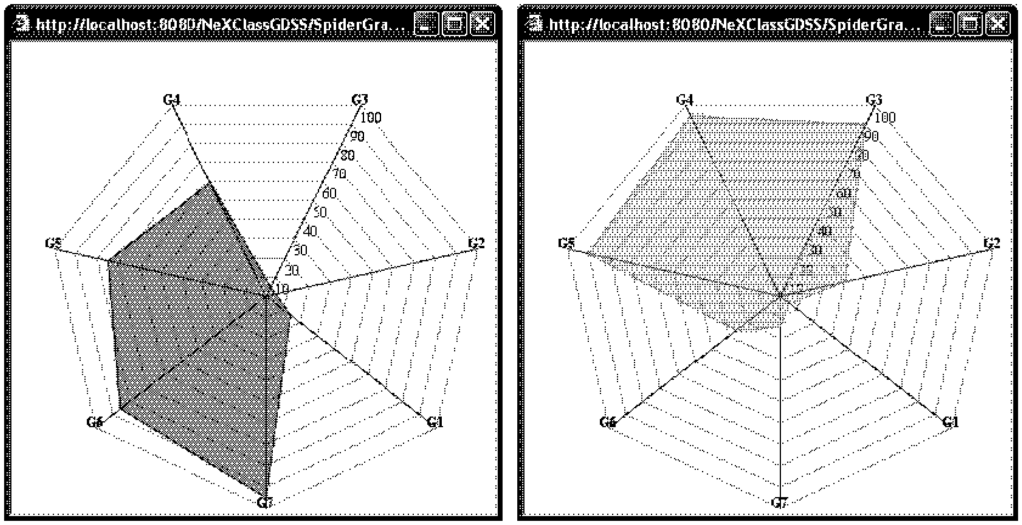

Fig. 6: Graphs depicting category' thresholds

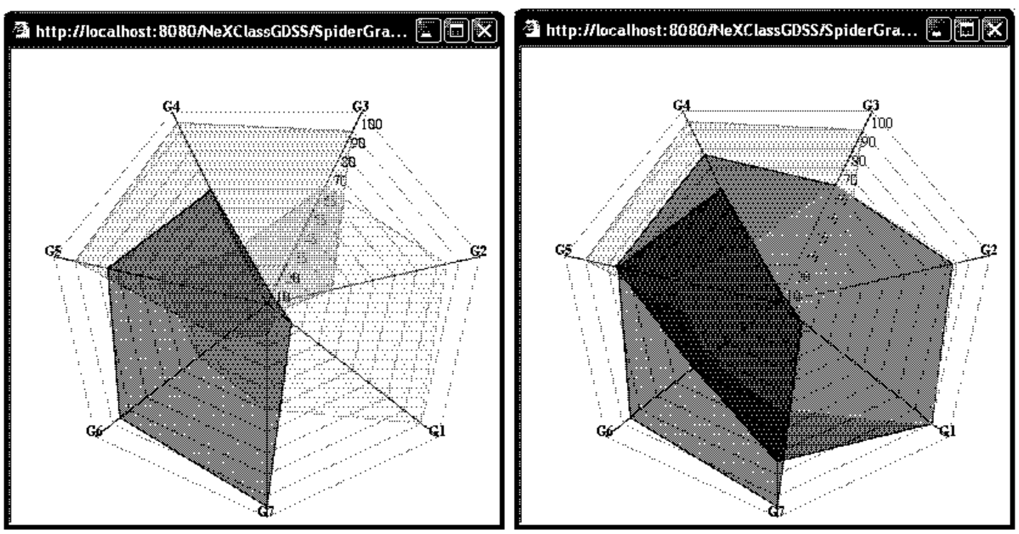

Fig. 7: Graphs depicting alternative's score and category thresholds

acceptance level for each alternative (Fig. 8). As it can be seen from this reference set, classification results satisfy at high level group members.

From the application in the bank environment, as well as the overall operation of the GDSS we conclude that the group decision methodology and the GDSS provide a valid way to groups to solve classification problems.

However, the following limitations exist regarding the problems that can be solved by the methodology

- Since the methodology requires a relative substantial number of parameters, it is possible that group members who are not familiar enough with the methodology will be confused. Thus, the number of criteria and parameters should be kept to a number, which will minimize complexity without however loosing critical problem parameters.
- Another limitation is that the number of members should be kept within the limits of a small collaborating team. If members are quite a few, anonymity is not so well established since preferences can be easily identified. On the other hand, a large number of members will increase the complexity and extra facilitation will be necessary.

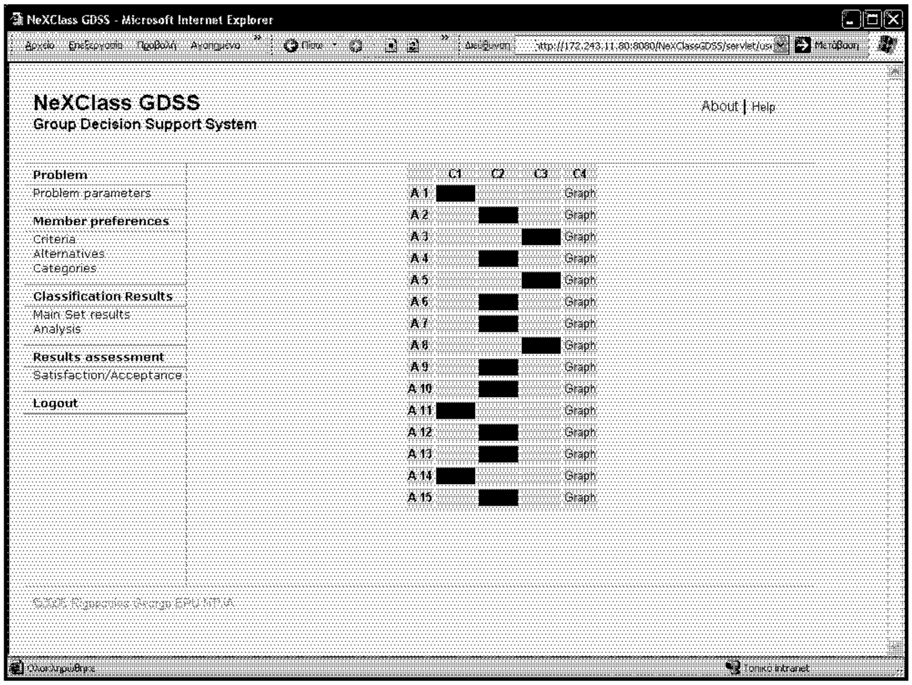

Fig. 8: GDSS screen depicting classification results (ATM locations to categories)

Table 5: Criteria weights

	Member									
Weight	M1	M2	M3	M4	M5	M6	M7	M8	M9	Group value
G1	15	17	13	15	11	12	18	15	15	14.8
G2	25	23	21	24	23	21	21	27	25	22.8
G3	5	6	7	8	8	9	10	3	5	7.2
G4	12	11	12	10	16	14	12	12	12	12.2
G5	8	7	13	5	5	9	4	8	8	7.3
G6	25	26	22	27	28	22	29	25	25	25.3
G7	10	10	12	11	9	13	6	10	10	10.3

Table 6: Categories' entrance thresholds

		Member									
Category	Criterion	M1	M2	M3	M4	M5	M6	M7	M8	M9	Group
	G1	90	91	92	88	87	89	90	92	88	89.72
	G2	85	82	90	89	81	88	83	87	82	84.36
C1	G3	60	63	62	66	58	62	66	58	57	61.25
	G4	30	33	32	36	26	29	29	27	29	29.23
	G5	50	50	51	58	43	47	51	47	49	49.54
	G6	47	36	37	44	47	32	38	36	43	40.11
	G7	46	57	54	48	45	44	57	47	49	49.60
	G1	5	9	2	8	7	9	2	2	8	5.74
	G2	30	32	30	29	31	28	33	37	22	30.31
C2	G3	90	93	82	86	88	92	96	88	91	89.73
	G4	95	93	92	86	96	99	99	87	89	94.46
	G5	90	90	91	88	83	87	91	97	89	89.83
	G6	25	26	27	34	17	22	28	26	23	25.71
	G7	15	17	14	8	15	14	17	11	12	14.70
	G1	17	13	12	18	17	16	12	13	14	14.32
	G2	5	3	4	2	7	8	3	5	7	4.77
C3	G3	5	3	6	6	8	4	6	3	3	4.61
	G4	60	63	62	66	56	59	59	57	59	59.23
	G5	75	70	71	78	83	77	71	77	79	74.79
	G6	85	86	87	84	87	82	88	86	83	85.81
	G7	95	97	94	98	95	94	97	91	92	95.08

Table 7: Alternatives' aggregated scores to evaluation criteria

Alternative	G1	G2	G3	G4	G5	G6	G7
A1	99	90	78	34	54	43	56
A2	8	34	99	99	99	27	22
A3	21	9	9	63	77	88	97
A4	90	80	61	33	55	39	50
A5	28	56	51	80	90	99	91
A6	41	35	44	29	34	21	47
A7	50	6	54	25	38	21	47
A8	49	17	54	61	78	86	98
A9	49	43	28	29	61	22	67
A10	29	22	28	25	69	25	61
A11	91	88	69	39	89	47	61
A12	18	67	92	96	100	32	49
A13	25	28	34	25	46	32	49
A14	90	82	61	77	76	49	74
A15	61	44	34	26	37	21	40

Table 8: Alternatives' classification to categories

Alternative	Category	Group acceptance level
A1	C1	High
A2	C2	High
A3	C2	High
A4	C2	High
A5	C2	Medium
A6	C2	High
A7	C2	High
A8	C2	High
A9	C2	High
A10	C2	Medium
A11	C1	Medium
A12	C2	High
A13	C2	High
A14	C1	High
A15	C2	High

Concluding, the GDSS provides a structured way to solve classification problems, defining steps in a clear way, so group members can adopt the methodology relatively fast. The designed web interface provides an easy way to members to contribute their preferences, without having to collaborate in a specific place and time and facilitator can easily form a virtual team, set the timeframe for members' response and coordinate the entire process. Empirical findings from GDSS application have been analyzed and provide evidence that the methodology and the GDSS provide a valid approach for group decision problems in business environment. We believe that this methodology and GDSS can be easily deployed to support group decisions in similar environments.

REFERENCES

Bui, T.X., 1987. Co-oP: A Group Decision Support System for Cooperative Multiple Criteria Group Decision Making. Springer-Verlag Berlin Heidelberg, Germany.

Carlsson, C., D. Ehrenberg, P. Eklund, M. Fedrizzi, P. Gustafsson, P. Lindholm, G. Merkuryeva, T. Riisanen and A.G.S. Ventre, 1992. Consensus in distributed soft environments. Eur. J. Operat. Res., 61 (1-2): 165-185.

Cil, I., O. Alpturk and H.R. Yazgan, 2005. A new collaborative system framework based on a multiple perspective approach: InteliTeam. Decision Support Syst., 39 (4): 619-641.

Colson, G. and B. Mareschal, 1994. JUDGES: A descriptive group decision support system for the ranking of the items. Decision Support Syst., 12: 391-404.

Csaki, P., L. Csiszar, F. Folsz, K. Keller, Cs. Meszaros, T. Rapcsak and P. Turchanyi, 1995. A flexible framework for group decision support WINGDSS Version 3.0. Ann. Operat. Res., 58: 441-453.

Deer, P., F. Modave and T. Tilley, 2001. Web-based collaborative multicriteria decision making. In: Proceedings of 1st International Conference on I.T. Bangkok, Thailand.

Espinasse, B. and T. Pauner, 1995. NegocIAD: A multi-criteria and multi-agent system for negotiation support. In: Proceedings of International Workshop on the Design of Cooperative Systems, INRIA, Antibes-Juan-les-Pins, France.

Geldermann, J., K.J. Zhang and O. Rentz, 2003. Multi-criteria group decision support for integrated technique assessment. In: Proceedings of 57th Meeting of the European Working Group of Multiple Criteria Decision Aiding, Viterbo.

Genova, K., V. Vassilev, F. Andonov, M. Vassileva and S. Konstantinova, 2004. A multicriteria analysis decision support system. In: Proceedings of the 5th International Conference on Computer Systems and Technologies, Rousse, Bulgaria.

Iz, P.H., 1992. Two multiple criteria group decision support systems based on mathematical programming and ranking methods. Eur. J. Operat. Res., 61 (1-2): 245-253.

Jarke, M., M.T. Jelassi and M.F. Shakun, 1987. MEDIATOR: Toward a negotiation support system. Eur. J. Operat. Res., 31 (3): 314-334.

Karacapilidis, N.I. and T. Gordon, 1995. Dialectical planning. In Proceedings of the 14th IJCAI Workshop on Intelligent Manufacturing Systems, Montreal, pp: 239-250.

Kersten, G.E., 1985. NEGO-group decision support system. Inform. Manage., 8 (5): 237-246.

Kim, J.K. and S.H. Choi, 2001. A utility range-based interactive group support system for multiattribute decision making. Comput. Operat. Res., 28 (5): 485-503.

Lewandowski, A., 1989. SCDAS-decision support system for group decision making: Decision theoretic framework. Decision Support Syst., 5 (4): 403-423.

Lu, J., M.A. Quaddus, K.L. Poh and R. Williams, 1999. The design of a knowledge-based guidance system for an intelligent multiple objective decision support system (IMODSS). In: Proceedings of 10th Australian Conference on Information Systems.

Matsatsinis, N.F. and A.R. Samaras, 2001. MCDA and preference disaggregation in group decision support systems. Eur. J. Operat. Res., 130 (2): 414-429.

Noori, H., 1995. The design of an integrated group decision support system for technology assessment. R.D. Manage., 25 (3): 309-322.

Nunamaker, J.F., A.R. Dennis, J.S. Valacich, D.R. Vogel and J.F. George, 1991. Electronic meeting systems to support group work. Commun. ACM., 34 (7): 40-60.

Pongpeng, J. and J. Liston, 2003. TenSeM: A multicriteria and multidecision-makers' model in tender evaluation. Construct. Manage. Econ., 21: 21-30.

Quaddus, M.A., D.J. Atkinson and M. Levy, 1992. An application of decision conferencing to strategic planning for a voluntary organization. Interfaces, 22 (6): 61-71.

Raju, K.S. and D.N. Kumar, 1998. Group decision support system for multicriterion analysis a case study in India. In: Proceedings of International Conference on Information Technology, CIT-98, Bhubaneswar, India, pp: 149-154.

Rangaswamy, A. and G.R. Shell, 1997. Using computers to realize joint gains in negotiations: Toward an electronic bargaining table. Manage. Sci., 43 (8): 1147-1163.

Roy, B., 1991. The outranking approach and the foundations of ELECTRE methods. Theor. Decision, 31: 49-73.

Teckle, A., P.B. Shrestna and L. Duckstein, 1998. A Multiobjective decision support system for multiresource forest management. Group Decision Negotiat., 7: 23-40.

Vetchera, R., 1994. GDSS-X: An Experimental Group Decision Support System for Program Planning. In: Multicriteria Analysis, Climaco, J. (Ed.). Proceedings of the XIth International Conference on MCDM, Coimbra, Portugal, Springer, Berlin.

Vihakapirom, P., 2002. A proposed framework of a web-based multicriteria group decision support system in distributed synchronous meetings. Minor Thesis for MSC School of Computer Science and Software Engineering, Monash University.

Yager, R.R., 1988. On ordered weighted averaging aggregation operators in multicriteria decision making. IEEE. Trans. Syst. Man Cybernet, 18: 183-190.

Yager, R.R., 1993. Families of OWA operators. Fuzzy Set Syst., 59 (2): 125-148.