Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER Computers and Mathematics with Applications 50 (2005) 1543–1558
An International Journal
computers & mathematics with applications
www.elsevier.com/locate/camwa

Recruitment and Selection Processes Through an Effective GDSS

HSU-SHIH SHIH*
Graduate Institute of Management Science
Tamkang University
151 Ying-Chuan Rd., Tamsui, Taipei, Taiwan 25137, R.O.C.
hshih@mail.tku.edu.tw

LIANG-CHIH HUANG
Institute of Labor Studies
National Chung Cheng University
168, University Rd., Min-Hsiung, Chia-Yi, Taiwan 621, R.O.C.
lchuang@ccu.edu.tw

HUAN-JYH SHYUR
Department of Information Management
Tamkang University
151 Ying-Chuan Rd., Tamsui, Taipei, Taiwan 25137, R.O.C.
shyur@mail.im.tku.edu.tw

(Received July 2005; accepted August 2005)

Abstract—This study proposes a group decision support system (GDSS), with multiple criteria to assist in recruitment and selection (R&S) processes of human resources. A two-phase decision-making procedure is first suggested; various techniques involving multiple criteria and group participation are then defined corresponding to each step in the procedure. A wide scope of personnel characteristics is evaluated, and the concept of consensus is enhanced. The procedure recommended herein is expected to be more effective than traditional approaches. In addition, the procedure is implemented on a network-based PC system with web interfaces to support the R&S activities. In the final stage, key personnel at a human resources department of a chemical company in southern Taiwan authenticated the feasibility of the illustrated example.

Keywords—Group decision support systems, Recruitment and selection processes, Decision quality, Consensus, Multiple criteria analysis, Human resource.

*Author to whom all correspondence should be addressed.
The authors would like to thank the human resources department of a local chemical company in southern Taiwan, Dr. Young-Jou Lai at Dollar Thrifty Automobile Group, Tulsa, OK, Dr. E. Stanley Lee at Kansas State University, U.S.A., Mr. L.D. Jiang at Lite-on Semiconductor Corp., Professor Hai-Ming Chen and Miss Hsiao-Jun Huang at Tamkang University and Ming-Deng Huang, Jin-Yi Ho and Tsia-Yu Chen at I-Shou University, Taiwan for their valuable help. Special thanks are given to National Science Council, Taiwan, R.O.C., for the financial support under the grant numbers: NSC 90-2218-E-214-010, NSC 91-2213-E-032-035, and NSC 92-2213-E-032-032.

0898-1221/05/$ - see front matter Typeset by $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TEX
doi:10.1016/j.camwa.2005.08.026

1. INTRODUCTION

Recruitment and selection (R&S) processes are important practices for human resources management (HRM), and are crucial in affecting organizational success [1]. Due to the fact that firms are always fortified by information technology to be more competitive, it is natural to also consider utilizing this technology to reorganize the traditional R&S processes through proper decision techniques, in hopes that both the effectiveness and the efficiency of the processes can be increased and the quality of the R&S decision improved.

A human resource information system (HRIS), is a system exploited to acquire, store, manipulate, analyse, retrieve, and distribute relevant information regarding an organization's human resources [2]. The purpose of the system is to support human resources services from the strategic level down to the tactical and operational levels. Many decision-making problems, including recruitment and selection, are herein involved. The system facilitates automated or computerized procedures to solve the problems, and is of vital importance as an aggressive tool in the information age [3].

From a practical viewpoint, in handling HRM problems, a decision support system (DSS), once established, can do the work. The DSS is a computer-based information system that combines models and data in an attempt to solve unstructured problems with extensive user involvement through a friendly user's interface [4]. A DSS can be defined as four essential aspects:

(i) language system;
(ii) presentation system;
(iii) knowledge system; and
(iv) problem-solving system [5].

Turban and Aronson [6] also configured a DSS with the four similar subsystems:

(i) data management;
(ii) model management;
(iii) knowledge-based management; and
(iv) user's interface.

This can be viewed as a third-generation computer-based application. In addition, it couples the intellectual resources of individuals with the capabilities of computers to help make HRM-related decisions.

The applications for DSSs for HRM are still currently being developed. Niehaus [7] implements a series of human resource planning DSSs for the U.S. Navy shipyard community. Bellone *et al.* [8] present a DSS, ISPM, for personnel career management for an Italian steel mill. Mohanty and Deshmukh [9] propose a DSS for human resources planning at an Indian petroleum company. Recently, Vitolo and Vance [10] developed a DSS, STEP-UP, for transforming the dislocated workers of the Philadelphia Navy Shipyard. We can see that these advanced applications are less in public, the progress of HRIS implementation is a perfect example, which had been slow until the 90s [2]. Presently, many related information systems are focused on e-recruitment on the web (e.g., [11–13]). In addition, in 2000, recruitment, selection, and placement are the top three issues of HRM [14], and many computerized human resources systems are used for these practical applications [3,15]. Therefore, the requirements for a DSS to contribute to any HRM practice are still demanding, and it is just this that motivates our study.

In view of the fact that certain groups constantly make complex decisions in different organizations; a group decision support system (GDSS) or group support system is developed for this particular reason to support collaborative and interactive works [16]. Group support is a critical issue for DSSs this century, with emphasis on communication, computer technologies, and work methodologies [6]. The system can assist the individual parties to prepare for negotiations or to help structure the negotiations so that a mutually beneficial solution will be found [17]. The GDSS is an interactive, computer-based system, or computer-supported cooperative work system, which offers solutions to unstructured problems through the brainstorming of concerned decision makers (DMs) working together as a group [18]. Thanks to the concurrent mass usage of network and internet infrastructure, methods in decision analysis can be fully exploited. Also, some complex real-world problems can be tracked through an integration of various decision techniques combined with information technologies.

As decision quality has drawn much attention in decision making in the past, systems that provide a systematical procedure to guarantee qualified decisions are here to stay. Group decision making (GDM) can obtain multiple sources of knowledge and experience [19], and the decision quality is thus improved. In addition, the concept of multicriteria decision making (MCDM) or multiple attributes decision making can also help DMs identify the essence of the problems from diverse aspects, and its decision quality can be enhanced [20]. These two quantitative techniques can be imbedded into a DSS or GDSS, promoting a better choice through scrutinized aggregation, and, to say the least, a better solution can be designed through an experimental study [21]. In addition, a couple of consensus indices are proposed and try to measure the disparity of the group opinion quantitatively [22]. Thus, decision quality will be improved if the consensus indices can be integrated into the processes, thereby assuring the effectiveness of the R&S processes. Furthermore, Nunamaker *et al.* [23] summarize the evolution of the DSS concept and introduce ten directions of future study within organizations. Within these ten directions of future study two directions, generalized and integrated systems, and increased decision making effectiveness and efficiency, are the main aims of our study.

The paper is organized as follows. First, the concept of the DSS is introduced, combining GDM and MCDM for the R&S processes. Second, a literature survey is made and the aim of the study will be identified. Third, with an unstructured problem being illustrated, a problem-solving procedure for the processes is first defined, then relevant techniques are chosen and placed in each corresponding step. The fourth part reveals how information technologies, related to models, databases, and interfaces, are utilized to realize a prototype system. In the final part, an example is tested to prove that the recommended system is applicable.

2. LITERATURE SURVEY

To follow the purpose of our study, we will explore the literature in two parts: group decision support systems, and decision quality. Accordingly, the proposed work can be spotlighted.

2.1. Group Decision Support Systems

A group decision support system is designed to provide decision aid to groups or organizations [24]. Since solving complex problems requires that people collaborate in modern organizations, the GDSS has drawn much attention in the last two decades. Due to the complexity of GDSSs with various information technologies and activities, many pioneers try to classify the developing systems into adequate categories. Communication being the first concern of GDSSs, DeSanctis and Gallupe [18] initially propose three levels of systems based on an information-exchange perspective for decision making. Level 1 attempts to reduce communication barriers through information infrastructure, Level 2 tries to overcome process difficulties by adding decision techniques, and Level 3 aims at enhancing the control of timing, content, or message patterns exchanged by participants through an active regulated decision process. In addition, based on differences in group size and dispersion of group members, four environmental settings are placed allowing the GDSS design and other technologies to be compatible. On the other hand, following the categories of DSSs by Alter [25], i.e., the extent to which system outputs can be directly determined, Mallach [26] further distinguishes GDSSs into data-oriented, and model-oriented issues. Recently, Holsapple and Whinston [27] made an exhaustive investigation into multiparticipant decision support systems, and introduced three related areas: GDSSs, organizational DSSs, and negotiation support systems. These three areas are supported by technologies in the field of organizational computing, which include: coordination technology, computer-supported cooperative work, groupware, and computer-mediated communication. Furthermore, the technological infrastructure should fit within the organizational infrastructure in three respects: roles, relationships, and regulations [28]. Therefore, an integrated system is to be designed to work on these aspects for an organizational decision, and group activities can be performed for different places, times, and types of organizations.

From the viewpoint of decision analysis, numerous techniques, in the areas of multicriteria/attribute decision making, multiobjective decision making, and group decision making, can help DMs make a better choice. These techniques are naturally incorporated into GDSSs to facilitate an efficient decision. Applied with multiple criteria, Iz and Gardiner [16] have reviewed GDSSs as discrete alternative problems and multiple objective programming problems; and each includes thirteen studies and twelve studies. Based on the essence of the input rendered by the DM, Davey and Olson [21] also classify multicriteria GDSSs as, value-oriented, and goal-oriented (the former yields nine systems, the latter five systems), and examine the effectiveness of the systems. In addition, because we are dealing with a problem-solving process, e.g., Binbasioglu's two-phased problem solving strategy [29] for real-world model building, an integrated model is needed to incorporate different group tasks, which include generating, choosing, and negotiating [18], and many complex systems can be developed. Therefore, we roughly make an extension of Iz and Gardiner's category [16] as shown in Figure 1, which adds another dimension to the purpose of problem-solving and alternative-selecting/generating, versus previous types of problems. Since selection and ranking of finite candidates is our target, the category of discrete alternative problems or of valued-oriented systems would be our development assets, and we position them in the upper right-hand cell of Figure 1.

		The Purpose of the Systems	
		Alternative-selecting/ generating	**Problem-solving**
The Type of the Problems	**Discrete alternative problems**	a. Bui [30] b. TeamEC [31]	Our approach
	Multi-objective programming problems	a. Iz [32] b. no commercial software yet	N/A

Note:

1. Since the literature survey is not exhaustive, we only list a representative work in each block of the figure.

2. In the left side blocks, the systems proposed in articles are marked with a and the commercial software are marked as b. In addition, most commercial software is classified as alternative-selecting for discrete alternative problems.

3. Despite the possible overlap of the selecting techniques, we roughly classify the GDSS on two dimensions to emphasize the difficulty of problem-solving on the platform of information infrastructure.

Figure 1. The classification of multicriteria GDSSs.

Note that we only list a representative work in each cell of the figure on account of an inefficient survey. Nonetheless, this classification tries to emphasize the difficulty of problem solving within the framework of information infrastructure. The study will also have a connection with the architecture of commercial GDSS environments as pointed out by Benbasat and Konsynski [33].

Although most presented GDSSs try to solve problems in the real world, the lack of an integrated procedure, from decision identification, basic information acquiring, to final decision proposed, makes the systems only partially supportive or even needful of outside assistance. Realized with the redesign of the R&S processes, our prototype system will demonstrate the advantage of supplementing the aforementioned deficiency. Still, despite the existence as well as extensive use of numerous general-purpose commercial software, e.g., TEAMEC [31] and GROUPSYSTEMS (see [6]), it is our belief that these softwares do not readily fulfill the needs or operational usages of specialists or experts in different organizations to render their expertise in GDM processes. It is this belief that propels our study.

2.2. Decision Quality

Decision quality is an essential element in making decisions. A decision with high quality not only will be regarded as a prime choice but definitely also facilitates the ease of its execution at a later time. Now that we are concerned with the problem-solving procedure, decision quality must be considered throughout the procedure. The procedure concentrates on the coherence of techniques involved for ensuring a superior result [34].

Conceptually, MCDM techniques can help DMs distinguish the kernel of a complicated problem by identifying different criteria on a categorized basis, thus achieving a multidimensional decision. Since the problem is thus scrutinized, we shall see that MCDM can provide better decision than from that of a single criterion, and compromises to group conflicts can be achieved. However, these techniques usually assume that the set of criteria or attributes are predefined or there exists some kind of consensus before the MCDM process starts. The prerequisites are obtained through a task group of more than one DM or expert in practice. Therefore, it is perceivable that the group interactions will be time-consuming activities while optimal choice matures [35].

To overcome the above-mentioned drawback, one branch of efforts tackles the development of an integrated GDSS for the tasks of cooperative groups in decision environments characterized by the existence of multiple, conflicting criteria [16]. Aiming at streamlining the interactions among different DM groups, GDM techniques, especially in the category of group participation, try to control the conflicts among group members and obtain multiple sources of knowledge and experience [36]. Moreover, these techniques are designed to increase the creative productivity of group actions, facilitate group decisions, help stimulate the generation of critical ideas, give guidance to the aggregation of individual judgments, and leave DMs with a sense of satisfaction [37]. Afterwards, the decision quality of the system can thus be secured after the judgments are reasonably arranged, and they are especially good for higher difficulty tasks [38]. On the other hand, the effectiveness of GDSSs has been significantly justified after an empirical study, but decisions with better quality is not noteworthy [21]. In addition, Schmidt *et al.* [39] further demonstrate virtual teams/groups making the most effective decisions among individuals, face-to-face teams, and virtual teams/groups. Thus, we can conservatively say that multicriteria GDSSs do help groups make a more effective decision than do traditional approaches.

3. DECISION PROCESSES AND RELATED TECHNIQUES

As we establish decision support for the R&S processes in organizations, a number of DMs or experts will involve the function of human resources for a long period of time. The processes are first described in this section. Several common techniques of MCDM, GDM, and relevant consensus contents, are discussed to expound the complex processes at different steps that illustrate how an effective decision is obtained.

3.1. Recruitment and Selection Processes

To be a high performance organization, HRM must be able to assist the organization to place the right person in the right job. The HRM practices include recruitment, selection, placement, evaluation, training and development, compensation and benefits, and retention of the employees of an organization. Businesses have developed HRISs that support:

(i) recruitment, selection, and hiring;
(ii) job placement;
(iii) performance appraisals;
(iv) employee benefits analysis;
(v) training and development; and
(vi) health, safety, and security [40].

The first few activities of HRM are recruiting and selecting which deal with the actions concerned, and the recruiting is also less frequently alerted in HRIS recently [3]. Besides, as previously mentioned, e-recruitment on the web being the current trend for the R&S processes, we can further distinguish many activities of the processes. Dessler [15] lists the essence of these in the following:

(i) build a pool of candidates for the job;
(ii) have the applicants fill out application forms;
(iii) utilize various selection techniques to identify viable job candidates;
(iv) send one or more viable job candidates to their supervisor;
(v) have the candidate(s) go through selection interviews; and
(vi) determine to which candidate(s) an offer should be made.

Mondy *et al.* [41] also propose a generalized selection process, which covers similar activities, with nine steps. Dale [42] illustrates the exchange and flow of information during the R&S processes with sixteen activities. Its detailed descriptions study Dessler's six point list [15], and its contents will be the target of our development. To support the R&S processes, a DSS or GDSS can be modified to handle these activities, and an effective decision can be made.

3.2. Group Consensus

Despite the importance of examining decision quality, group consensus seems to be a relevant issue for the quality of group decision. We will go to the area of group consensus to support our study.

Although techniques of MCDM and GDM have been effective tools for decision making, the inherent difference among a group needs to be investigated quantitatively to reach a generally accepted level. In such a way, consensus is introduced as a general agreement of the group or agreement across individuals based upon the same data, and it has a positive impact on accuracy and then success in making decisions [43,44].

To manage the consensus quantitatively in GDM with multiple criteria, Saaty [45] first suggests taking a geometric mean of individual judgment as the group judgment for analytic hierarchy process (AHP) (see [46]). Basak and Saaty [47] further investigate the consensus of preference rankings of individuals among a large number of people through stochastic approach. Madu [48] then introduces a quality confidence procedure for applying AHP in the GDM environment, and outliers can be identified. Bryson [49] further points out that wide disparities in the comparison of information could result in the computed consensus matrix being an inaccurate representation of the given situation at the human level. With this in mind, he and Ngwenyama *et al.* [22] then propose three indicators to estimate the level of group consensus and another three individual consensus indicators, which rely on the angles of two preference vectors, and some judgments will be made by the value of cosine/sine. Because the relative location of two vectors with the same angle might generate different values, the threshold values for strong agreement and disagreement would be meaningless. Therefore, Lin [50] further suggests making use of the nonnormalized preference vectors through Chen's similarity measure [51] and combining it with the above six indicators to evaluate agreement and disagreement of the group. Recently, Condon *et al.* [52] utilized a Sammon map to visualize the preference vectors of DMs from AHP hoping that a common group goal would be reached. In addition, Shih *et al.* [35] take advantage of arithmetical mean further to generate three relevant indices to measure the preference vectors among the group, and detect and visualize the outliers through three ranking indices. These pioneering works will both enrich and shape a new development in our study.

Because the weights of criteria are our focus, much effort is made to deal with individual preference and group opinion. To simulate the decision making process, we simplify Lin's concept [50] to solely consider two indicators, group preference agreement indicator (GPAI), on criteria, and group preference similarity indicator (GPSI), on weights of criteria. Both are calculated through the agreement grouping indicator (AGG) of Ngwenyama *et al.* [22], but the further calculation is simplified by taking nonnormalized preference vectors. Here, GPAI = Average(IPAI(DMi)), for each member $i = 1, \ldots, k$, and IPAI(DMi) $= \sum_{i=1}^{k-1} \sum_{q=i=1}^{k} 2AGG^{t,r}/[k(k-1)]$ for any group member t and r. Also, GPSI = Average(IPSI(DMi)), $i = 1, \ldots, k$, and IPSI(DMi) will take the maximization of any two vectors instead of the inner product of the vectors. In addition, the former is to check whether DMs really accept these criteria as important, and the latter is to check whether the preference vector for criteria of each DM tilts up toward the strong agreement of the group. The threshold of GPAI on criteria is set at the value of cosine with the angle less than 45í, depending on a loose or a strict requirement. Here, we set the value at 0.866, equal to cos(30í) (see [22]). The threshold of GPSI on weights of criteria is set at 0.8554, a simulated result from different angles (less than the angle of 15í, which is proposed by Ngwenyama *et al.* [22]) as well as the ratio of the length of two vectors (from 0.1 to 1.0). These two threshold values act as the judgment for group consensus, and the consensus process shall proceed as desired until these two thresholds are met.

Besides being obtained from empirical studies, these two values can be changed according to the decision attitude of the group. In addition, we think this rectification, with it's proven ease of use throughout process, shall indeed detect the difference and improve the work of Ngwenyama *et al.* [22]. Let's illustrate the computation with an example.

Example 1. Five members of a group anonymously rank a personnel requirement using the seven attributes, and provide their original preference data as shown in Table 1.

Table 1. Basic data of the preference vector of the group.

	Group				
	Member 1 (DM#1)	Member 2 (DM#2)	Member 3 (DM#3)	Member 4 (DM#4)	Member 5 (DM#5)
Attribute 1	1.104	1.219	1.000	1.000	1.000
Attribute 2	1.000	1.219	1.000	1.104	1.346
Attribute 3	1.000	1.104	1.104	1.104	0.906
Attribute 4	1.000	1.219	1.104	1.104	1.104
Attribute 5	1.104	1.219	1.000	1.000	1.000
Attribute 6	1.000	0.610	0.906	1.000	0.820
Attribute 7	0.820	0.673	0.906	0.743	0.906
Length	2.6666	2.8262	2.6606	2.6850	2.7100

Note:
(1) There are the seven attributes to be evaluated by the group with five members.
(2) The first member of the group is assigned as DM#1, e.g., decision maker 1, and DM#2, DM#3, DM#4, and DM#5 are numbered in sequence.

To reflect the consensus composed of the length and the angle of the preference vectors, we use their nonnormalized preference vector, from a pairwise comparison, instead of Ngwenyama *et al.*'s normalized vector of AHP [22]. Thus, we propose GPAI, replacing their group strong agreement quotient, to judge if any criterion is important enough to be accepted for further processing. Here, the GPAI = 0.9882 for the five members, and it is greater than the threshold value 0.866.

Table 2. The calculation of agreement indicator AGG of the group(an inner product of two preference vectors.)

	DM#1	DM#2	DM#3	DM#4	DM#5
DM#1	*	7.3955	7.0651	7.1300	7.1272
DM#2	—	*	7.3835	7.4583	7.5341
DM#3	—	—	*	7.1208	7.1282
DM#4	—	—	—	*	7.1983
DM#5	—	—	—	—	*

Note:
(1) Please check Ngwenyama *et al.* [22] for the definition of an agreement indicator AGG.
(2) "*" indicates that no calculation of the inner product of any preference vector itself.
(3) "—" indicates that the value is omitted because it is the same as the symmetric side of the diagonal line of the matrix.

Table 3. The calculation of individual preference agreement indicator (IPAI).

	DM#1	DM#2	DM#3	DM#4	DM#5
DM#1	—	0.9813	0.9958	0.9958	0.9863
DM#2	0.9813	—	0.9819	0.9829	0.9837
DM#3	0.9958	0.9819	—	0.9968	0.9886
DM#4	0.9958	0.9829	0.9968	—	0.9893
DM#5	0.9863	0.9837	0.9886	0.9893	—
IPAI(DM_i)	0.9898	0.9825	0.9908	0.9912	0.9870

Note:
(1) IPAI(DM_i) is the average of the value of each column i.

Table 4. The calculation of individual preference similarity indicator (IPSI).

	DM#1	DM#2	DM#3	DM#4	DM#5
DM#1	—	0.9529	0.9935	0.9890	0.9705
DM#2	0.9529	—	0.9244	0.9338	0.9433
DM#3	0.9935	0.9244	—	0.9706	0.9886
DM#4	0.9890	0.9338	0.9706	—	0.9801
DM#5	0.9705	0.9433	0.9886	0.9801	—
IPSI(DM_i)	0.9697	0.9318	0.9691	0.9727	0.9661

Note:
(1) IPSI(DM_i) is the average of the value of each column i.

Please check the calculation in Tables 2 and 3. That means that the seven attributes listed in Table 1 are worthy of further consideration.

In addition, we further calculate GPSI to understand the group consensus on the weights of criteria. Here, the GPSI = 0.9619 for the five decision makers and it is greater than the threshold value 0.8554. Please check the detailed calculation in Table 4. This means consensus on the weight of the criteria for each member has been reached.

Observe that the measure of disparity of the group preference or opinion can be based on attributes, alternatives, attributes' weights, or other elements of decision making (see [35]). We have just noted an important part in this section.

	Decision technique	Conflict existence	Time/Place occurrence
Step 1. Definition of recruitment and selection requirements 1.1) Establishment of requirements of recruitment; 1.2) Clarification of personnel requirement for the job; 1.3) Creation of a set of criteria; 1.4) Determination of minimum achievement for each criterion.	General discussion	group	same/different
⇩			
Step 2. Identification of selection criteria for the requirements 2.1) Silent generation of criteria in writing; 2.2) Round-robin recording of criteria; 2.3) Serial discussion of the list of criteria; 2.4) Voting for necessary criteria.	NGT	group	same/different
⇩			
Step 3. Elicitation of weights of criteria by individuals 3.1) Establishment of a reciprocal matrix for criteria' comparison; 3.2) Calculation of criteria' weights by pair-wise comparison; 3.3) Check for consistency of priority of the matrix for himself/herself.	AHP	individual	same/different
⇩			
Step 4. Consensus facilitation for group judgment 4.1) Derivation of GPAI for agreement on criteria.; 4.2) Examination of GPSI for agreement on weights of criteria.	Consensus indices	group	same/different

Figure 2. The first phase of the recruitment and selection processes (preprocess).

	Decision technique	Conflict existence	Time/Place occurrence
Step 5. Establishment of a pool of applicants. 5.1) Recruitment from various resources. 5.2) Establishment of a database for keeping applicants' status.	Data entry	No	different/different
⇩			
Step 6. Screening and evaluation of applicants along a timetable. 6.1) Rejection of applications by background investigation; 6.2) Elimination of applicants with low test achievement; 6.3) Removal of applicants through structured interview(s). 6.4) Notification of unsuitable applicants. 6.5) Possession of ranking results of candidates.	Criteria' thresholds and ranking	group	different/different
⇩			
Step 7. Accumulated evaluation of candidates by individual. 7.1) Accumulation of evaluation on each criterion for candidates; 7.2) Construction of the normalized decision matrix; 7.3) Construction of the weighted normalized decision matrix; 7.4) Determination of PIS and NIS; 7.5) Calculation of the separation measure; 7.6) Calculation of the relative closeness to the PIS; 7.7) Ranking of the candidates.	TOPSIS	individual	same/same
⇩			
Step 8. Selection of suitable candidates. 8.1) Aggregation of the evaluation results from individuals; 8.2) Ranking of the candidates. 8.3) Notification of the candidates, successful and unsuccessful.	Borda's function	group	same/same

Figure 3. The second phase of the recruitment and selection processes (selection process).

3.3. Decision Process

As mentioned above, a couple of MCDM and GDM techniques with consensus indices are revised for the R&S processes to secure an effective decision. These techniques are organized as a problem-solving procedure to support a decision [35]. The procedure is reorganized to fit the activities of Dessler's R&S processes [15] step by step.

Because of the considerable time span of the R&S processes, the problem-solving procedure cannot be executed in a conference room where hectic actions are the norm. To fit the characteristics of different times and places, the operation is revised as a two-phase procedure. The first phase concentrates on acquiring basic decision information, which does not necessarily change over time or with the different locations of the R&S's execution. Conflicts can arise within the group and among the individuals and must be dealt with. The acquired decision information can thus be stored for later use or as a reference for later recruitment. A series of preprocessed actions is illustrated in Figure 2, which covers the acquisition of selection criteria, minimum achievements, and weight factors on criteria with consensus. The second phase brings a series of selection actions described in Figure 3, which are based on the given decision information to choose suitable candidates. They are actions to manage the selection process for a specific job within an organization. Note that we may roughly classify the first phase as planning or preprocess, and the second phase as operation or selection.

Besides the pertinent activities and corresponding decision techniques listed in each step in Figures 2 and 3, we also distinguish each step from the aspects of conflict existence, and the time/place of occurrence. Conflict existence will be for individuals or in the group, depending on the techniques involved in MCDM or GDM, respectively. The time/place of occurrence process describes related activities happening at the same or different times and at the same or different places, and is supported by different information technologies as appropriate. Note that these aspects will be future GDSS issues to be paid attention to as pointed out by DeSanctis and Gallupe [18] and Hatcher [53].

It is observed that, after checking the contents of each step, one statement will be drawn up explaining why we chose a specific technique for each step. We think that nominal group technique (NGT), AHP, the technique for order preference by similarity to ideal solution (TOPSIS), and Borda's function (a social choice function) are rather common techniques and easy to use. The MCDM and GDM techniques can be consistently aggregated as an integrated procedure. In addition, AHP is taken for eliciting the weights of criteria due to its objectiveness. However, we take advantage of TOPSIS for further evaluation to avoid ranking reversal and accommodating a great many candidates.

While we check Figure 2, the first step (Step 1) is to define R&S requirements, which includes four activities. Since participators or DMs might not be familiar with the requirements or how to evaluate a specified job, they shall take time to orient themselves with some background information, review job descriptions and job specifications, exchange ideas about requirements, create abundant criteria, and determine the minimum achievement for each criterion through a general discussion. Afterwards, in Step 2, the generated criteria are filtered, merged, and refined to capture the essence of the requirements by NGT (see [37]). The third step (Step 3) tries to elicit the weights of the necessary criteria of each DM through a well-known pair-wise comparison technique, AHP (see [46]). The last step, Step 4, concentrates on consensus facilitation for group judgment (see [22,50]). Two consensus indices are modified to examine the criteria and their weights quantitatively, and the preference vectors are forced to be redefined if the threshold is not crossed. Otherwise, the weights of criteria would be appropriate for the requirements of a specific job under some kind of consensus.

While the basic decision information is collected, the process goes to the second phase shown in Figure 3. This phase will deal with selection of applicants in practice scheduled on a timetable. The first activity (Step 5) is to establish a pool of applicants, and then the applicants' data can be obtained from inside or outside resources. After a company opens job vacancies in public, interested applicants will apply for the job through a given channel, even on the web. A human resources department will establish a database keeping track of the applicants' status. The subsequent step is related to a series of activities of review, tests, and interview. The results of each activity will be kept for later use. Certain applicants will be screened out through criteria' thresholds (Step 6) (see [54]). The applicants who stand out shall be the candidates for the specified job and be evaluated at different criteria levels with TOPSIS by each DM, respectively (Step 7) (see [20]). After all DMs have completed the evaluation, Step 8 will illustrate the aggregation of individual rankings as a whole through Borda's function (see [36]). Therefore, the group decision will be made concerning the successful and unsuccessful candidates in the final step. Note that interested readers may refer to Shih *et al.* [35] for detailed descriptions of the above techniques.

In addition, the proposed two-phase procedure has been shown to cope with the R&S processes in the real world with the help of a human resources department from a chemical company in southern Taiwan. The end result was quite successful as well as effective due to the support of various decision techniques. An efficient decision will actually be ensured through the help of information technology [55].

3.4. Selection Methods

As we have discussed a couple of decision techniques for the R&S processes before, these techniques will be combined with the selection methods of HRM sequentially on the timetable. In fact, the techniques of MCDM are used to evaluate candidates from different aspects. These aspects can be considered as several selection methods, which include reference and background checks, employment interviews, selection tests (i.e., cognitive aptitude test, psychomotor abilities test, job knowledge test, work sample test, vocational interest test, personality test), review of applications and resumes, assessment centers, and preliminary interview [41]. These tests and interviews will be executed as a sequenced process in Step 6 of the R&S processes in Figure 3.

Then again, the reliability and validity of tests as well as interviews are all important issues on account that the candidates with the right skills and criteria shall do a better job for the company [15]. Taylor [56] has investigated the accuracy of some methods of selection, and found that work sample tests and ability tests outperform other methods. In addition, many pioneers have explored the validity issues of computer-based testing, and provided suggestions for a more valid measurement (e.g., [55]). Despite not entailing these issues, their results do support our development in obtaining a robust decision; to say the least, the more efficient methods will be given more weight than the rest from a multiple criteria standpoint.

4. IMPLEMENTATION OF THE SYSTEM

Employing a broad range of decision analysis tools, we will establish an integrated procedure for the R&S processes in an environment of network-based PCs with web interfaces. It is categorized as a multiple criteria GDSS for discrete alternatives problems [16]. In order to trace the designated steps, the system will support work at the same time/place and at different times/places, and provide tools on individual/group tasks with a small number of experts in organizations. Moreover, it is also recognized as a DeSanctis and Gallupe's level 3' GDSS [18] without inference facilities. Let's introduce the system through the viewpoints of system architecture and process as follows.

4.1. System-Architecture Description

To characterize our GDSS, we designate a GDSS engine and other common subsystems, such as databases, model base, and user's interfaces, as illustrated in Figure 4. The personnel database is to maintain a pool of applicants' status and keep the necessary decision information derived from Phase 1. The inner database will keep the knowledge relevant to the requirements of a specific job and other supporting information. The model base covers all decision techniques listed in Figures 2 and 3. The user's interfaces allow communication bi-directionally between the system and its users, including general members and the chairman via the GDSS engine. The engine acts as a control center for the system, and it connects previous components allowing communication, collaboration, and decision making. It helps plan the agenda, acquire and store information and knowledge, stream the processes, and direct decision activities for the integrated R&S process on the system.

The system is established on networked-based PCs in the MICROSOFT WINDOWS environment. Due to the fact that collaborative work is executed over the web, user's interfaces thus become the most sophisticated part of the system. The functions of all user's interfaces (the chairman and general members) rely on their given roles. Moreover, the main structure of the interfaces is

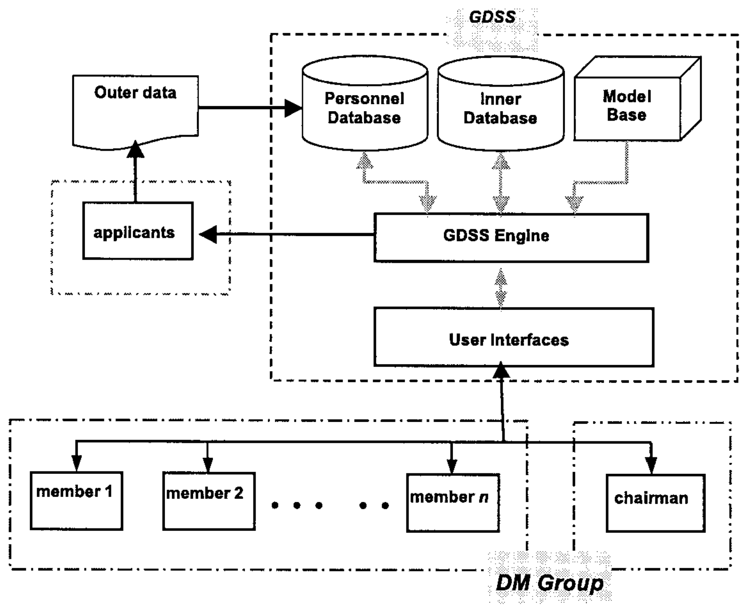

Figure 4. The configuration of the proposed system.

comprised of three parts: menu, input, and output interfaces. The menu builds a list on the left of the screen to remind users and provide online help, including chat room, decision processes, help, etc. The input interface sends user's inquiries or required operations to the server end via the active server page (ASP) at each step. After the process has been handled by a decision technique in the model base or a MICROSOFT SQL database, the processed information is sent back to the output interface via the ASP. The results can then be shown in the form of tables or judgments, to assist DMs in proceeding to the next step. Because of the characteristics of frequent data refreshing and less load on the ASP, users and the system can be left in a stable and interactive environment. In addition, unlike other developed GDSSs (e.g., [31]), the coordination and consensus facilitation have been monitored positively in our process, resulting in highly improved decision quality.

4.2. Process Description

To demonstrate the ability of our proposed system, we will illustrate the whole process through an example. In the first phase, the chairman of the group logs onto the system initially and selects a sufficient amount of members or experts from different function areas of the company. After all members have logged on, a general discussion will be conducted in the chat room to define the R&S requirements. A NGT will help to obtain a set of necessary criteria. Afterwards, each member will elicit weights to the criteria through a pair-wise comparison of AHP (Figure 5) and consistent checks will be carried out automatically. To reach a consensus, two indices, GPAI and GPSI, are checked and repeated with the pair-wise comparison until a level of satisfactory agreement is reached.

In the second phase, a series of R&S activities will be conducted interactively. After the human resources department establishes an applicants' database, screening and evaluation activities will be served through background investigations, tests, and interviews, respectively. Using the example of recruiting on-line managers, the relevant selection tests (provided by a human resources department from a local chemical company in southern Taiwan) are suggested as: knowledge tests (including language test, professional test, and safety rule test), skill tests (including professional skills and computer skills), and interviews (including panel interview and one-to-one interviews). Also, the results of personality tests (including Holland code, DISC measurement, and leader

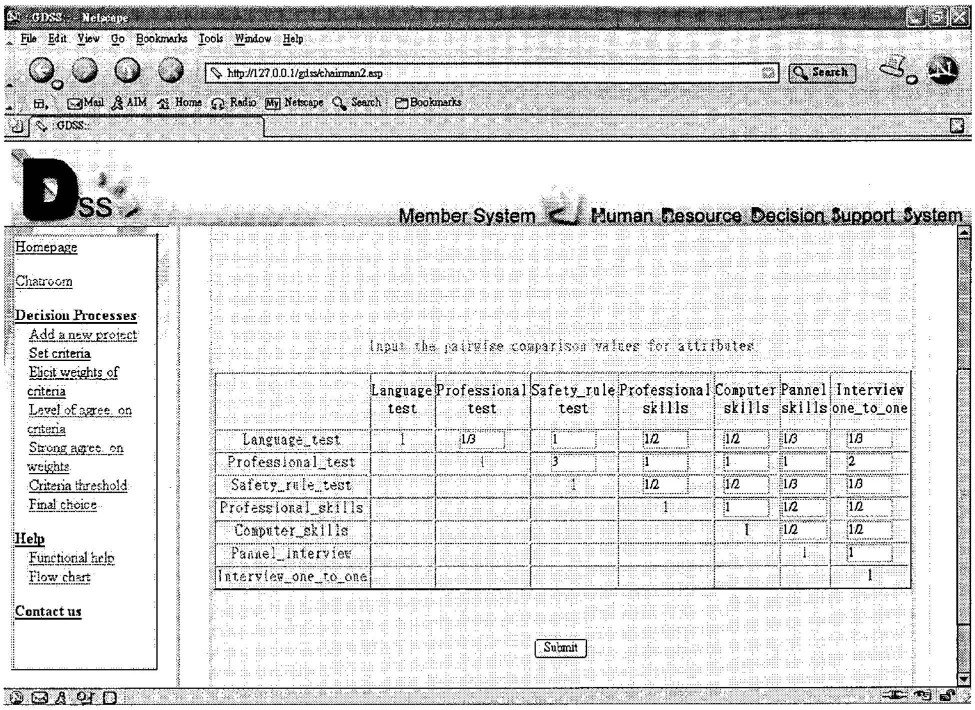

Figure 5. Pairwise comparison for the weights of criteria by a decision maker.

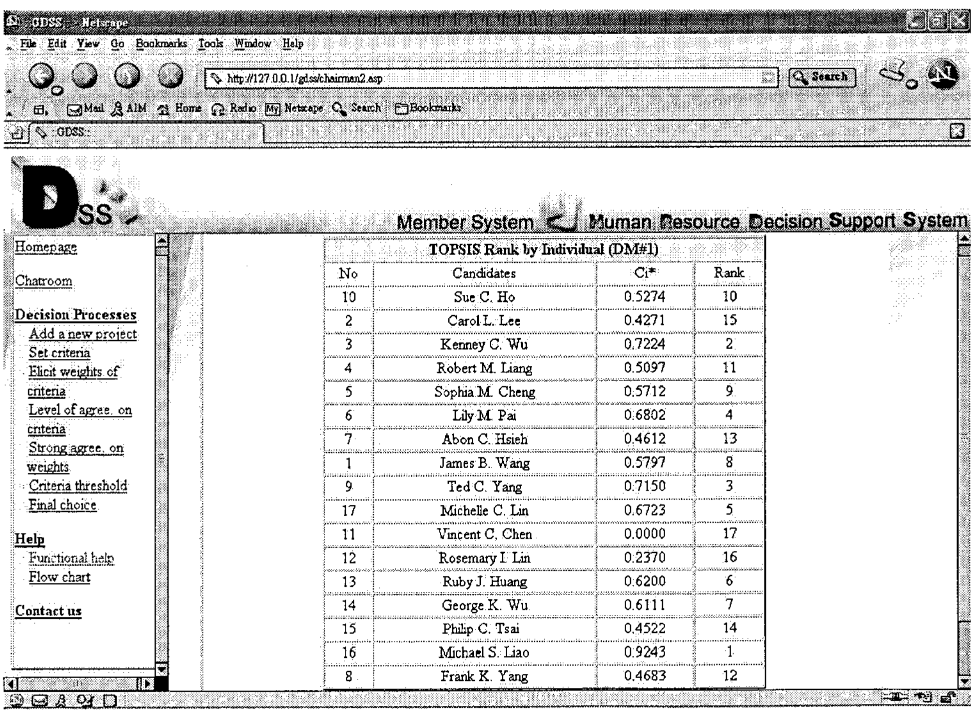

Figure 6. TOPSIS result by one decision maker (DM#1).

adaptability) are kept for reference in the beginning to ensure the suitability of the applicants. In addition, the upper and lower bounds are accumulated from each member to eliminate undesired applicants. If an applicant's performance were over the minimum standard on each of the criterion, he or she would then be a candidate for further selection. By using TOPSIS, each

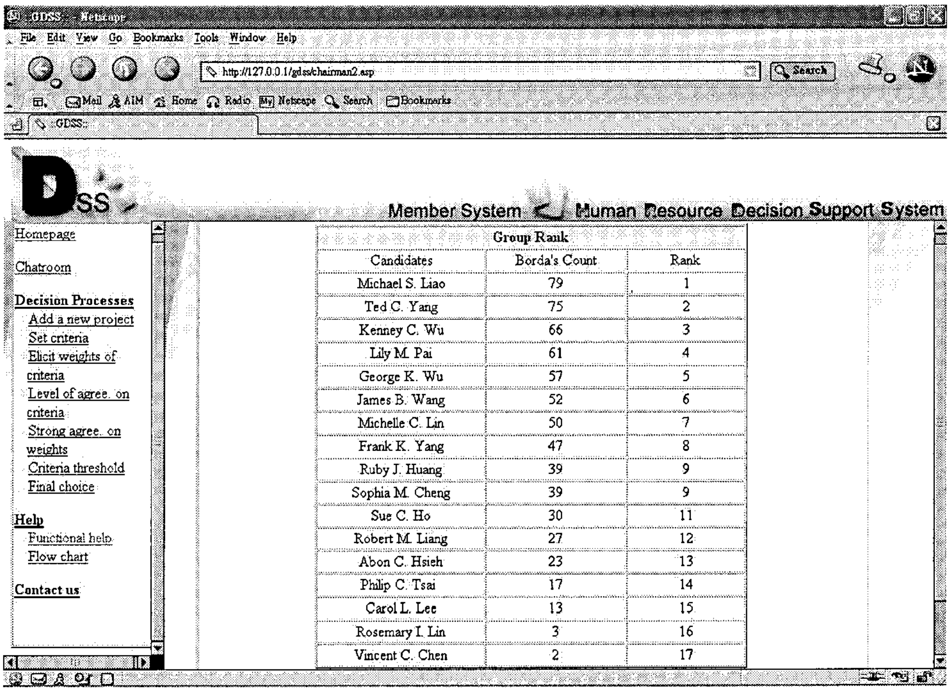

Figure 7. The final choice aggregating through Borda's count.

member can rank their ratings regarding each candidate in the background mode (Figure 6). In the final step, the whole group, through Borda's function or Borda's count, will tally their ratings to finalize the forerunners and render a group recommendation (Figure 7). The prototype system was examined by the company last year.

It is observed that the human resources department will usually provide the core competencies of any specific job requirements. The requirements have an impact on the criteria and their weights in the decision-making processes. Therefore, the criteria, and weights of on-line managers might not be suitable for secretaries. Nevertheless, the basic information will be handled in Phase 1 and the necessary contents of examinations and interviews would be varied in Phase 2 of the R&S processes.

In a final note, there may be instances in which DMs would be different from one phase to the next. In our system, the name and the number of DMs can be adjusted to reflect these differences.

5. CONCLUSIONS AND REMARKS

We have proposed an integrated decision model and implemented a multicriteria GDSS for the R&S processes. After combining several decision techniques with consensus enhanced in a computerized environment, the established system shows the competency of a much more effective and efficient analytic tool than traditional ones. In addition, the suggested prototype has been checked through an example by the human resources department of a chemical company in southern Taiwan. Thus, the illustrated example has empirically verified the feasibility of our study. Moreover, the designed system offers the commercial GDSS environments a different version of architecture. With minor modification, it has great potential to fit other firms. In this regard, we also expect to carry out research for a large-scale feedback study in the future.

The recent survey shows that recruitment and selection are the top priorities for HRM. Our proposed system is valuable for implementing the selection process. Besides the illustrated example, the system is suitable for different job requirements. In addition, the concept of the system is showing the promise of adopting many other HRM practices.

Selecting the right person for the right job is important, and the choice of selection methods is pivotal judging from the different aspects of HRM. Although many works discuss the validity of assessments, even with some experimental studies, it is not the object of our system to integrate this issue at the present time. There is no doubt that the richness of validity development can enhance the robustness of our proposed multicriteria GDSS.

The role, as a facilitator, of the GDSS is to help the DM group make use of the system, and coordinate all activities on the path towards a final suggestion. As the complexity of the system grows, so does the need for a facilitator. Whatever the case might be, we assign his or her role as the chairman in our prototype system, and online help functions and a hard copy menu are offered for assistance. Setting an independent role is a direction for future development.

Even though we concentrate on the coherence of techniques to provide a qualified decision, the quality of individual and group judgments indeed affects the quality of decision [57]. It has not been investigated in this study since we assume that the quality of the decision by a group of DMs would be better than a single DM after a combination of multiple sources of knowledge and experience as in Raghunathan's study [58]. Furthermore, other experimental issues on group decision, e.g., decision perceptions, group size, groupthink, and decision style in different organizations, also have some kind of effect upon making a decision. These will be preserved for future study.

REFERENCES

1. A.E. Barber, *Recruiting Employees: Individual and Organizational Perspectives*, Sage, Thousand Oaks, CA, (1998).
2. M.J. Kavanagh, H.G. Gueutal and S.I. Tannenbaum, *Human Resource Information Systems: Development and Application*, PWS-KENT, Boston, MA, (1990).
3. K.S. Ball, The use of human resource information systems: A survey, *Personnel Review* **30** (5/6), 677–693, (2001).
4. R.H. Sprague, A framework for the development of decision support systems, *MIS Quarterly* **4**, 1–26, (1980).
5. R.H. Bonczek, C.W. Holsapple and A.B. Whinston, *Foundations of Decision Support Systems*, Academic, New York.
6. E. Turban and J.E. Aronson, *Decision Support Systems and Intelligent Systems*, Sixth Edition, Prentice Hall, Upper Saddle River, NJ, (2001).
7. R.J. Niehaus, Evolution of the strategy and structure of a human resource planning DSS application, *Decision Support Systems* **14**, 187–204, (1995).
8. M. Bellone, M. Merlino and R. Pesenti, ISPM: A DSS for personnel career management, *Decision Support Systems* **15**, 219–227, (1995).
9. P.R. Mohanty and S.G. Deshmukh, Evolution of a decision support system for human resource planning in a petroleum company, *International Journal of Production Economics* **51**, 251–261, (1997).
10. T.M. Vitodo and R.J. Vance, STEP-UP: Decision-support system for transforming the dislocated US defense workforce, *Interfaces* **32** (4), 75–83, (2002).
11. T.S. Brice and M. Waung, Web site recruitment characteristics: America's best versus America's biggest, *SAM Advanced Management Journal* **67** (2), 4–8, (2002).
12. E. Galanaki paper The decision to recruit online: A descriptive study, *Career Development International* **7** (4), 243–251, (2002).
13. SAP AG, Companies evolve HR strategies with E-recruiting solution from SAP, 4/27/2004 (Downloadable from website `http://www.sap.com/Company/Press/Press.aspx?PressID=2996`).
14. Anonymous, The top HR issues of 2000, *HR Focus* **77** (4), 1–15, (2000).
15. G. Dessler, *Human Resource Management*, Eighth Edition, Prentice-Hall, Upper Saddle River, NJ, (2000).
16. P.H. Iz and L.R. Gardiner, A survey of integrated group decision support systems involving multiple criteria, *Group Decision and Negotiation* **2** (1), 73–82, (1993).
17. P. Korhonen, H. Moskowitz and J. Wallenius, Multiple criteria decision support—A review, *European Journal of Operational Research* **63**, 361–375, (1992).
18. G. DeSanctis and B. Gallupe, Group decision support systems: A new frontier, *Data Base* **16** (4), 3–10, (1985).
19. G.M. Marakas, *Decision Support Systems in the 21st Century*, Prentice-Hall, Upper Saddle River, NJ, (1999).
20. C.L. Hwang and K. Yoon, *Multiple Attribute Decision Making*, Springer-Verlag, Berlin, (1981).
21. A. Davey and D. Olson, Multiple criteria decision making models in group decision support, *Group Decision and Negotiation* **7**, 55–75, (1998).
22. O.K. Ngwenyama, N. Bryson and A. Mobolurin, Supporting facilitation in group support systems: Techniques for analyzing consensus relevant data, *Decision Support Systems* **16** (2), 155–168, (1996).

23. J.F. Nunamaker, L.M. Applegate and B.R. Konsynski, Computer-aided deliberation: Model management and group decision support, *Operations Research* **36** (6), 826–848, (1988).
24. A. P. Sage, IEEE Control Systems, 29–33, (Aug. 1991).
25. S.L. Alter, *Decision Support Systems: Current Practice and Continuing Challenges*, Addison-Wesley, Reading, MA, (1980).
26. E.G. Mallach, *Decision Support and Data Warehouse Systems*, McGraw-Hill, NY, (2000).
27. C.W. Holsapple and A.B. Whinston, *Decision Support Systems: A Knowledge-based Approach*, West Pub., St. Paul, MN, (1996).
28. C.W. Holsapple and W. Luo, A framework for studying computer support of organizational infrastructure, *Information and Management* **31** (1), 13–24, (1996).
29. M. Binbasioglu, Key futures for model building decision support systems, *European Journal of Operational Research* **82** (3), 422–437, (1995).
30. T.X. Bui, *Co-op: A Group Decision Support System for Cooperative Multiple Criteria Group Decision Making*, Springer-Verlag, Berlin, (1987).
31. TeamEC, Expert choice 2000—Quick start guide and tutorial, Expert Choice Inc., Pittsburgh, PA, (2000).
32. P.H. Iz, Two multiple criteria group support systems based on mathematical programming and ranking methods, *European J. of Operational Research* **61** (1–2), 245–253, (1992).
33. I. Benbasat and B. Konsynski, Introduction to special section on GDSS, *MIS Quarterly* **12** (4), 588–590, (1988).
34. J.E. Matheson and M.M. Menke, Using decision quality principles to balance your R and D portfolio, *Research Technology Management* **37** (3), 38–43, (1994).
35. H.S. Shih, C.H. Wang and E.S. Lee, A multiattribute GDSS for aiding problemsolving, *Mathl. Comput. Modelling* **39** (11/12), 1397–1412, (2004).
36. C.L. Hwang and M.J. Lin, *Group Decision Making under Multiple Criteria*, Springer-Verlag, Berlin, (1987).
37. A.L. Delbecq, A.H. van de Ven and D.H. Gustafson, *Group Techniques for Program Planning*, Scott, Foresman and Company, Glenview, IL, (1975).
38. R.B. Gallupe and G. DeSanctis, Computer-based support for group problem-finding: An experimental investigation, *MIS Quarterly* **12** (2), 276–296, (1988).
39. J.B. Schmidt, M.M. Montoya-Weiss and A.P. Massey, New product development decision-making effectiveness: Comparing individuals, face-to-face teams, and virtual teams, *Decision Sciences* **32** (4), 575–600, (2001).
40. J.A. O'Brein, *Management Information Systems in the E-Business Enterprise*, Fifth Edition, McGraw-Hill, New York, (2002).
41. R.W. Mondy, R.M. Noe and S.R. Premeaux, *Human Resource Management*, Prentice Hall, Upper Saddle River, NJ, (1999).
42. M. Dale, *Successful Recruitment and Selection: A Practical Guide for Managers*, Kogan Page, London, (1995).
43. A.H. Ashton, Does consensus imply accuracy in accounting studies of decision making?, *The Accounting Review* **LX** (2), 173–185, (1985).
44. D. Murray and R.W. Regel, Accuracy and consensus in accounting studies of decision making, *Behavioral Research in Accounting* **4**, 127–139, (1992).
45. T.L. Saaty, Group decision making and the AHP, In *The Analytic Hierarchy Process*, Edited by B.L. Golden, E.A. Wasil and P.T. Harker, pp. 59–67, Springer-Verlag, Berlin, (1989).
46. T.L. Saaty, *The Analytic Hierarchy Process*, Second Edition, RWS Pub., Pittsburgh, PA, (1990).
47. I. Basak and T. Saaty, Group decision making using the analytic hierarchy process, *Mathl. Comput. Modelling* **17** (4/5), 101–109, (1993).
48. C.N. Madu, A quality confidence procedure for GDSS application in multicriteria decision making, *IIE Transactions* **26** (3), 31–39, (1994).
49. N. Bryson, Group decision-making and the analytic hierarchy process: Exploring the consensus-relevant information content, *Computers and Operations Research* **23** (1), 27–35, (1996).
50. W.Y. Lin, Implementation of a group decision model with imprecise multiple attributes (in Chinese), Master Thesis, Graduate School of Management, I-Shou University, Ta-Hsu, Kaohsiung, Taiwan, (2000).
51. S.M. Chen, A new approach to handling fuzzy decisionmaking problems, *IEEE Transactions on Systems, Mans, and Cybernetics* **18** (6), 1012–1016, (1988).
52. E. Condor, B. Golden and E. Wasil, Visualizing group decisions in the analytic hierarchy process, *Computers and Operations Research* **30**, 1435–1445, (2003).
53. M.E. Hatcher, Group decision support systems: Decision process, time and place, *Decision Support Systems* **8** (2), 83–84, (1992).
54. P. Vincke, *Multicriteria Decision-Aid*, John Wiley, Chichester, (1992).
55. K.L. Huff and S.G. Sireci, Validity issues in computer-based testing, *Educational Measurement: Issues and Practice* **20** (3), 16–25, (2001).
56. S. Taylor, *Employee Resourcing*, Beekman, NY, (2000).
57. H.J. Einhorn, R.M. Hogarth and E. Klempner, Quality of group judgment, *Psychological Bulletin* **84** (1), 158–172, (1977).
58. S. Raghunathan, Impact of information quality and decision-maker quality on decision quality: A theoretical model and simulation analysis, *Decision Support Systems* **26** (4), 275–286, (1999).