IEMS Vol. 1, No. 1, pp. 58-63, December 2002.

Development of a Web-Based Solution Builder for Three-Step Decision Support System

Heung-Suk Hwang†
Professor Department of Industrial Engineering
Dongeui University Busan, 614-714, KOREA
Tel: +82-51-890-1657, Fax: +82-51-890-1619, E-mail : hshwang@dongeui.ac.kr

Abstract. Recently a new multi-attribute analysis method is one of the evident areas of important points in the decision support system analysis. The area of decision support system may be broken into three primary area: idea generation, multi-attribute structured analysis method, and the integration of the results of analysis. This research developed an internet/intranet-based solution builder for a three-step decision support system in the view of 1) brainstorming for the idea generation, 2) analytic hierarchy process as a multi-attribute structured analysis method and 3) aggregating logic model to integrate the results of individual analysis. A computer program is developed and demonstrated in internet/intranet-based decision problem. This solution builder provides decision makers a good tool for remote group decision making

Keywords: decision support system, AHP, solution builder

1. INTRODUCTION

The purpose of this study is to develop an internet / intranet-based solution builder (Solution Builder 2001) for a three-step multi-attribute decision support system. A great deal of researches have been undertaken on decision support systems to determine the proper alternatives for example, operations research, mathematical models, and decision theory, while there are few researches to develop solution builders for these decision support systems based on internet / intranet including a group decision. Recently, information network and decision technology are applied together in effective decision support system to increase the decision efficiency. Most of the conventional concepts used in decision support systems do not seem to appropriate for modeling the kind of the internet/intranet based on characteristics. This paper is concerned with the development of a solution builder for decision support system and its software for the multi-attribute structured decision problems. In this research, we developed an integrated the decision support system based on tools; decision analysis methods, internet / intranet, and computer system as shown in Figure 1.

We used a two-step approach: 1) in step 1, we constructed decision alternatives and implemented the individual analysis using AHP (analytic hierarchy process) and fuzzy set ranking methodologies to overcome the special decision problems; those of multi-objective, multi-criterion, and multi-attribute, and 2) in step 2, we integrated the evaluation results of individual evaluation by reviewers. In this research, we developed and demonstrated a methodology for the decision makers to guide an internet / intranet based on decision support system using its computer programs. These programs transform several individual multi-criteria rank-ordered lists of decision alternatives into one aggregated and prioritized rank-ordered list. Also a literature survey about the majority-rule methods (MRM), a fuzzy set priority method was performed and these methods were known to be applicable to the aggregation of multiple criteria rank-ordered ordinal priorities. Figure 2 shows this three-step approach of the decision support system.

We compared the results with those by Criterion

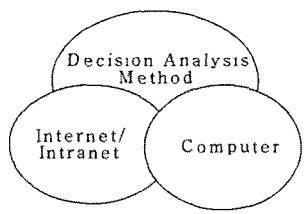

Figure 1. Decision support tools

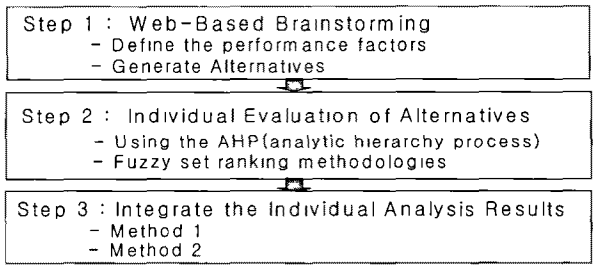

Figure 2. Three-step approach of decision support system

DecisionPlus v2.0 using the same example and we have got the same results.

2. INTERNET/INTRANET BASED SOLUTION BUILDER FOR DECISION SUPPORT SYSTEM

In this study, we developed a solution builder using GUI-type simulation software. We show the steps to solve alternatives for selecting the best choice through three steps of this solution builder. In step 1, to create the ideas to drive out alternatives from a group analysts, we used the brainstorming method based on an internet/intranet, and in step 2, we used the AHP method to evaluate the decision alternatives derived out in step 1 and determined the preferred alternative. In step 3, we integrated the results of individual evaluations into one ranked order. Also we developed two heuristic methods based on majority rule method a fuzzy set priority model. Figure 3 shows the schematic structure of three-step approach of this study.

This solution builder can be used as a decision support tool for the defense project evaluation, personal or public project evaluation based on network (internet/ intranet). This solution builder also can provide a good group decision support tool based on client and server. Figure 4 shows the structure of client/server based of intranet or internet.

The GUI-type program of Solution Builder-2001 consisted of main-program and brainstorming subroutine.

Figure 5 shows the structure of main-program. Computational experiments are then performed to sample systems and the effective performance of the proposed Model.

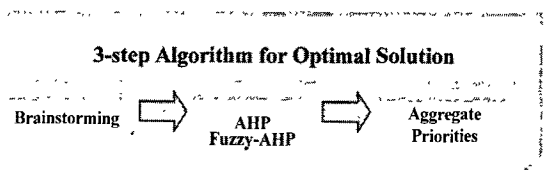

Figure 3. 3-step approach of decision support system

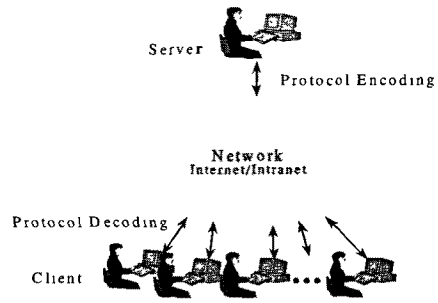

Figure 4. Client and server in decision support system

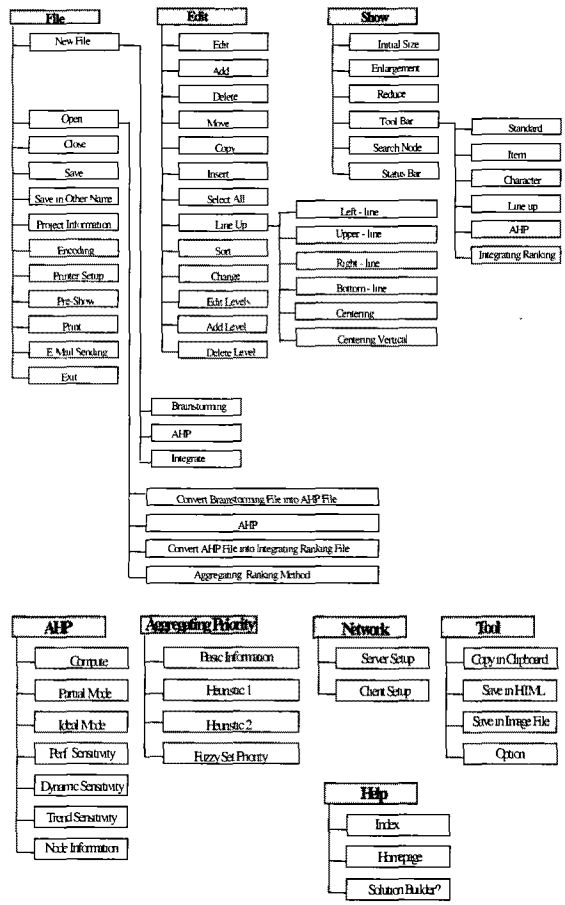

Figure 5. Main-program of Solution Builder-2001

2.1 Brainstorming

The alternatives evaluation and its method can be determined based on the system attributes and experiences of evaluators. To construct decision structures and alternatives, include the group decision ideas, and to create the ideas of alternatives for decision support system analysis of various groups, we used a brainstorming method. We developed a GUI-type program for users to use this method in the network-based environment without any problems. Figure 6 shows the structure of the brainstorming module.

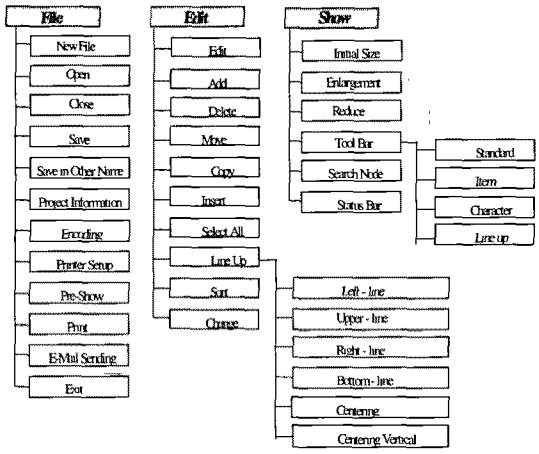

Figure 6. Brainstorming-program of Solution Builder-2001

Figure 7 shows a sample output of alternative generation and construct the decision structure of an example for school selection with 3-echelon structures and 3alternatives.

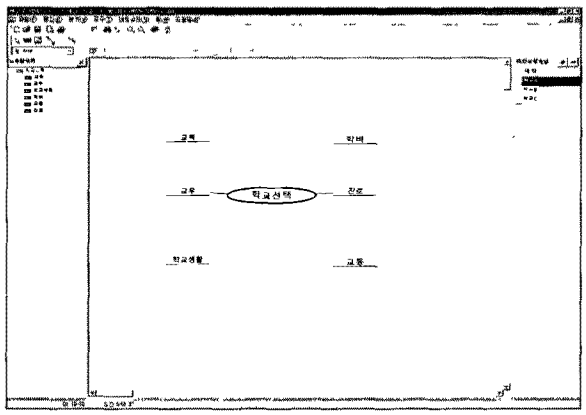

Figure 7. Sample output of brainstorming solution builder

2.2 Alternative Evaluation Using AHP

To create the ideas of alternatives and methods for decision support system analysis, we construct a decision structure using the brainstorming file in the internet/ intranet based on environment without any complexity. Also we developed a GUI-type program for users to use this method in the network based on environment without any problems. Figure 8 shows a sample output of alternative generation and constructs the decision structure of an example.

For the performance evaluation of decision alternatives, we used multi-echelon and multi-attribute analysis methods, AHP and fuzzy set priority methods (Zahedi, 1986). It is performed by 4 steps as following: 1) construct a hierarchical structure, 2) pair wise matrix of decision factors, 3) compute the weighted value, and 4) consistency

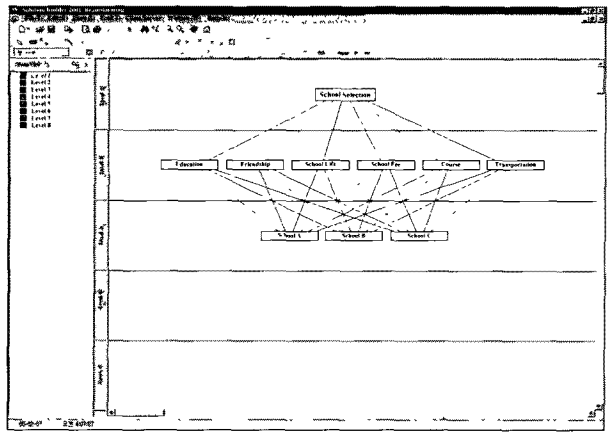

Figure 8. Decision structure and alternatives constructed by brainstorming file in the network environment

analysis. The solution builder consisted of main menu, tool bar, node editor, canvas and status bar as in Figure 8. For each level of structure, we find the eigenvalue by pair-wise comparison matrix based on Saaty's (1981) 9 point grading. Table 1 shows a sample outputs pair-wise matrix of sample problem. Figure 9 shows the final result of school selection problem using AHP, that is given by School B(0.378) > School A(0.367) > School C(0.255).

Table 1. Pair-wise comparison matrix

Level 1 CR=0.22

School Selection	Campus-Life	Edu-cation	Friend-ship	School Fee	Course	Trans	Eigen Value
Campus-	1	4	3	1	3	4	0.321
Education		1	7	3	1/5	1	0.140
Friend-			1	1/5	1/5	1/6	0.035
School Fee				1	1	1/3	0.128
Course					1	3	0.237
Transp-						1	0.139

CR=0.016

Campus Life	School A	School B	School C	Eigenvalue
School A	1	5	1	0.455
School B		1	1/5	0.090
School C			1	0.455

CR=0.046

Transportation	School A	School B	School C	Eigenvalue
School A	1	6	4	0.691
School B		1	1/3	0.091
School C			1	0.218

CR=0.024

Friendship	School A	School B	School C	Eigenvalue
School A	1	1	1	0.333
School B		1	1	0.333
School C			1	0.333

CR=0.034

Course	School A	School B	School C	Eigenvalue
School A	1	1/2	1	0.250
School B		1	2	0.500
School C			1	0.250

CR=0.180

School Fee	School A	School B	School C	Eigenvalue
School A	1	9	7	0.772
School B		1	1/5	0.055
School C			1	0.173

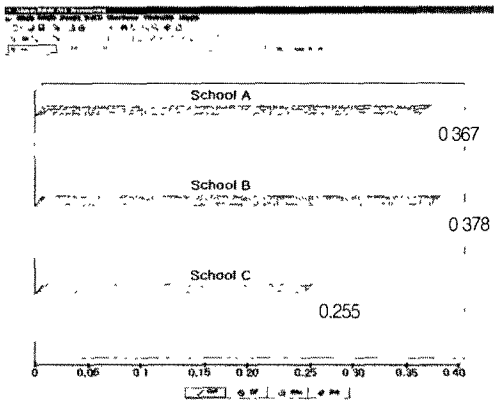

Figure 9. The AHP result of school selection problem

3. INTEGRATION OF INDIVIDUAL EVALUATION

For the integration of the results of individual evaluations, prioritized sets, we used two heuristic models; Heuristic Model 1, Model 2 and fuzzy set priority method which are a kind of majority-rule methods. These methods were compared to determine the most preferred alternative for the decision support system

3.1 Heuristic Model 1

In this method the preference score is given by the sum of the marks received from the evaluators, where for m alternatives, the marks are given, in decreasing order preference, (m − 1), (m − 2), ..., 0. The ranking was based on the scores of each alternative. In this case, the highest score will be the first priority. For example of the Heuristic Method 1, a sample result with $N = 5$ evaluators and $M = 3$

alternatives is given as :

Reviewer 1: B > A > C,
Reviewer 2: B > C > A,
Reviewer 3: C > A > B,
Reviewer 4: C > B > A,
Reviewer 5: C > B > A

Table 2. Example result of heuristic method 1

Alt.	Preference Matrix			Raw Sum	Weighed Value
School A	0.0	1.0	1.0	2.0	0.133
School B	4.0	0.0	2.0	6.0	0.400
School C	4.0	3.0	0.0	7.0	0.467
Heuristic Method 1 Rank Order	C > B > A				

The value of each cell of basic evaluation score matrix is given by "1" if the raw alternative wins against the column alternative, otherwise given by "0". In the summed frequency matrix the weighted value of the raw sum is the basis of rank order, thus the Heuristic Method 1 rank order is given by C(0.467) > B(0.400) > A(0.133).

3.2 Heuristic Model 2:

In this method, the evaluator frequency matrices were added to form a summed frequency matrix where a count was made for each alternative of the number of times it was preferred to each of the other alternatives. Then, the preference matrix was developed by a comparison of the scores in the component cells (A, B versus B, A). If the A, B value equals B, A, then each component cell in the matrix is given by "1/2". On the other hand if the A, B value is greater than the B, A, then A, B is given by "1" and B, A cell of the preference matrix is given by 0. The alternatives were ranked by the order of their preference matrix row sums and also we used fuzzy set priority method which is a kind of majority-rule methods. By applying the Heuristic Model 2 to the same example of Heuristic Method 1, the result is given by C(0.450) > A(0.392) > B(0.158) .

3.3 Fuzzy Set Priority Method

The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope with the kind of vagueness which cannot adequately be

represented by probability distributions. The model for this study had a limited capability to study the fuzzy set priority that could be obtained from the summed frequency matrix of Heuristic Model 2. The fundamental concept of fuzzy set priority relation R was derived from result by heuristic model 2. From the summed frequency matrix for complementary cells, A_{ij} and A_{ji} an additional fuzzy set matrix was made by considering $A_{ij} = 1 - A_{ji}$ for all cells. The fuzzy matrix complement cell values sum to 1 and fuzzy set difference matrix is defined as follows:

$$R-RT = U(\mathrm{A}, \mathrm{B}) - (\mathrm{B}, \mathrm{A}), \text{ if } U(\mathrm{A}, \mathrm{B}) > U(\mathrm{B}, \mathrm{A}),$$
$$= 0 \qquad \text{otherwise}$$
$$R-RT = U(\mathrm{A}, \mathrm{B}) - (\mathrm{B}, \mathrm{A}), \text{ if } U(\mathrm{A}, \mathrm{B}) > U(\mathrm{B}, \mathrm{A}),$$
$$= 0 \qquad \text{otherwise}$$

where, for $U(\mathrm{A}, \mathrm{B})$ quantifies, A is preferable to B.
To obtain fuzzy preferences, following five steps are considered:

Step 1: Find the summed frequency matrix (using Heuristic Method 2)
Step 2: Find the fuzzy set matrix R which is the summed frequency matrix divided by the total number of evaluators
Step 3: Find the difference matrix

$$R - RT = U(\mathrm{A}, \mathrm{B}) - U(\mathrm{B}, \mathrm{A}), \text{ if } U(\mathrm{A}, \mathrm{B}) > U(\mathrm{B}, \mathrm{A}),$$
$$= 0 \qquad \text{otherwise}$$

where, for $U(\mathrm{A}, \mathrm{B})$ quantifies, A is preferable to B.
Step 4: Determine the portion of each part
Step 5: The priority of the fuzzy set is then the rank order of X^{ND} values in decreasing

By applying the Fuzzy Set Priority Model to the same example of Heuristic Method, the result is given by A(0.38) > C(0.31) > D(0.30) > B(0.01).

3.4 Computer Program Development

We developed the computer program using C-language through the use of the module based tool and applied to a set of example problems of multi-structured decision support system. The computer model for this research emphasized the flexibility of programming options as well as future operational flexibilities for the improvement. The schematic flow diagram of the model is shown in Figure 10. The flexibility of the model encompasses the wide variety of areas to provide the methodology and tools to permit exploration research in such areas as fuzzy set priority, preference scoring constants, and comparative aggregation methodologies. Table 3 presents the comparison of sample runs between two heuristic and fuzzy set priority methods.

We applied this model to a set of examples of multi-structured decision support system as shown in Figure 2. First, we determined the weighted values by eigenvectors

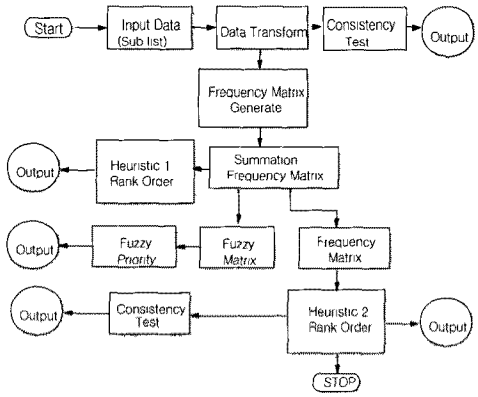

Figure 10. Schematic flow diagram of the proposed model

Table 3. Comparison of sample runs

Methods	Integrated Rank Order (Weighted Values)
- Heuristic Model 1	A > C > D > B, (0.34 0.28 0.21 0.17)
- Heuristic Model 2	A > D > C > B, (0.32 0.30 0.28 0.10)
- Fuzzy Set Priority Method	A > C > D > B (0.38 0.31 0.30 0.01)

of AHP and also by fuzzy set priority method.

Table 3 shows the comparison of results of both heuristic and fuzzy set priority methods.

4. SUMMARY AND CONCLUSIONS

We developed a solution builder based on the internet/intranet for a three-step decision support system in the view of multi-attribute evaluation using 1) brainstorming for the idea generation, 2) analytic hierarchy process as a multi-attribute structured analysis method, and 3) aggregating logic model to integrate the results of individual analysis. We used AHP, heuristic, and fuzzy set reasoning methods developed GUI-type program for the user's convenience. Finally, for a simple and efficient computation, computer program is developed and demonstrated in internet/intranet-based decision problem. This solution builder provides decision makers a good tool for remote group decision making. The proposed solution builder is validated by comparative computations for various multi-structured decision support examples. By the sample results of both AHP and fuzzy set reasoning method, it is known that the proposed solution builder is a good method for the performance evaluation of multi-attribute and multiple goals.

REFERENCES

Barbarosoglu, G. and Yazgas, T.(1997) Application of the analytic hierarchy process to the supplier selection problem, *Production and Inventory Management Journal*, **38**(1), 14-21.

Blin, J. M. (1974) Fuzzy Relations in Group Decision Theory, *International Journal of Cybernetics*, **4**(2), 17-22.

Criterium Decision Plus User Manual (1995) InfoHarvest, Eilram, L. M. (1991) Supply Chain Management: The Industrial organization Perceptive, *International Journal of Physical Distribution & Logistics Management*, **21**(1), 13-22.

Fishburn, P. C. (1971) A Comparative Analysis of Group Decision Methods, *Behavioral Science*, **16**, 538-544.

French, S. (1984) Interactive Multi-objective Programming: Its Aims, Applications and Demands, *Journal of Operation Research Society*, **35**(9), 827-834.

Itina, R. E. (1994) The Outsorcing Decision, *Management Accounting*, 56-62.

Kamarani, A. K. (1995) *Planning, Design, and Analysis of Cellular Manufacturing Systems*, Elsevier.

Murphy, C. K. (1995) Limits on the Analytic Hierarchy Process from Its Consistency Index, *European Journal. of Operation Research*, **65**, 138-139.

Leung Y. T. and Suri, R. (1990) Performance Evaluation of Discrete Manufacturing Systems, *IEEE Control Systems Magazine*, **10**(4), 77-86.

Richelson, J. T. (1975) A Comparative of Social Choice Functions, *Behavioral Science*, **20**, 331-342.

Robert, F. D., Ernest, H. F. (1991), *An Analytic Approach to Marketing Decisions*, Prentice Hall.

Saaty, T. L. (1981) *The Analytic Hierarchy Process,* McGraw-Hill, New York.

Shannon, R. E. (1986), The Amalgamation of Group Opinions or Evaluations, *Journal of Industrial Engineering*, **19**(6).

Zahedi, F. (1986) The analytic Hierarchy Process－A Survey of the Method and it's Applications, *Interfaces*, **16**(4), 96-104.