Web-based Three-step Project Management Model and Its Software Development

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Abstract

Recently the technical advances and complexities have generated much of the difficulties in managing the project resources, for both scheduling and costing to accomplish the project in the most efficient manner. The project manager is frequently required to render judgments concerning the schedule and resource adjustments.
This research develops an analytical model for a schedule-cost and risk analysis based on visual PERT/CPM. We used a three-step approach: 1) in the first step, a deterministic PERT/CPM model for the critical path and estimating the project time schedule and related resource planning and we developed a heuristic model for crash and stretch out analysis based upon a time-cost trade-off associated with the crash and stretch out of the project. 2) In second step, we developed web-based risk evaluation model for project analysis. Major technologies used for this step are AHP (analytic hierarchy process, fuzzy-AHP, multi-attribute analysis, stochastic network simulation, and web based decision support system. Also we have developed computer programs and have shown the results of sample runs for an R&D project risk analysis. 3) We developed an optimization model for project resource allocation. We used AHP weighted values and optimization methods. Computer implementation for this model is provided based on GUI-Type objective-oriented programming for the users and provided displays of all the inputs and outputs in the form of GUI-Type. The results of this research will provide the project managers with efficient management tools.

Keywords: Project Risk Analysis, Fuzzy AHP, Web-based Decision Analysis, Stochastic Network Simulation.

1. Introduction

With the advent of the large cost overruns and schedule slippages on many major development projects in the early nineties, the major project managers have realized the need for more efficient tool for project management and risk analysis (Zahedi, 1986). Decisions of project managers could be made and modeled within the network via time, cost and/or performance considerations. 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. We have developed an integrated decision support system based on tools; decision analysis methods, internet/intranet, and computer system as shown in Figure 1.
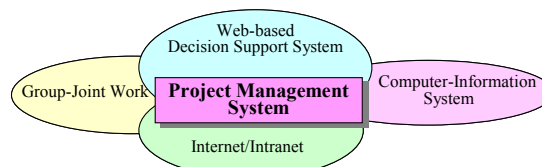

Figure 1. Project Management Structure

In this research, we have developed and demonstrated a methodology for the decision makers to guide an internet/intranet based on decision support system using its computer programs. Figure 2 shows the 3-step approach of the decision support system for project evaluation.

2. Individual Project Alternative Evaluation Using AHP

2.1 Web-Based Solution Builder

In this study, have we developed a solution builder using simulation software. We show the steps to solve alternatives for selecting the best choice through three steps of this solution builder. In the first step, to create 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 on evaluating the decision alternatives derived out in the step 1 and have determined the preferred alternative. In the last step, we have shown the integrated results of individual evaluation into one ranked order. We have developed two heuristic methods based on majority rule method. Figure 3 shows the schematic structure of 3-step approach.
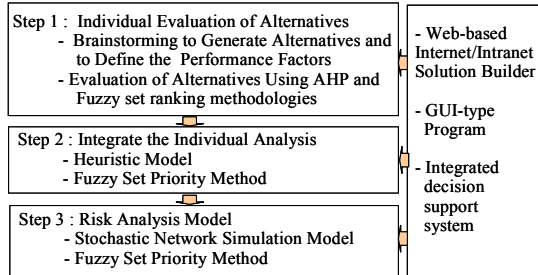

Figure 2. 3-step Approach of Project Evaluation Model

problem. Figure 4 show a system composed by Client and Server in Decision Support System.
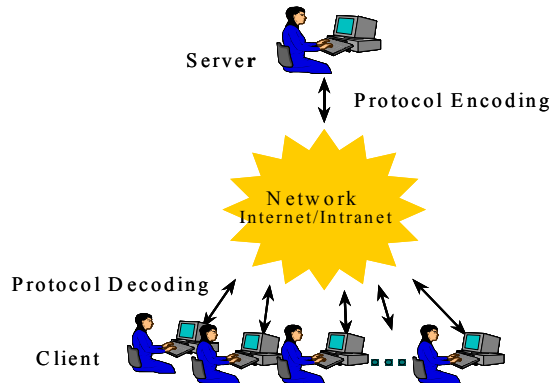

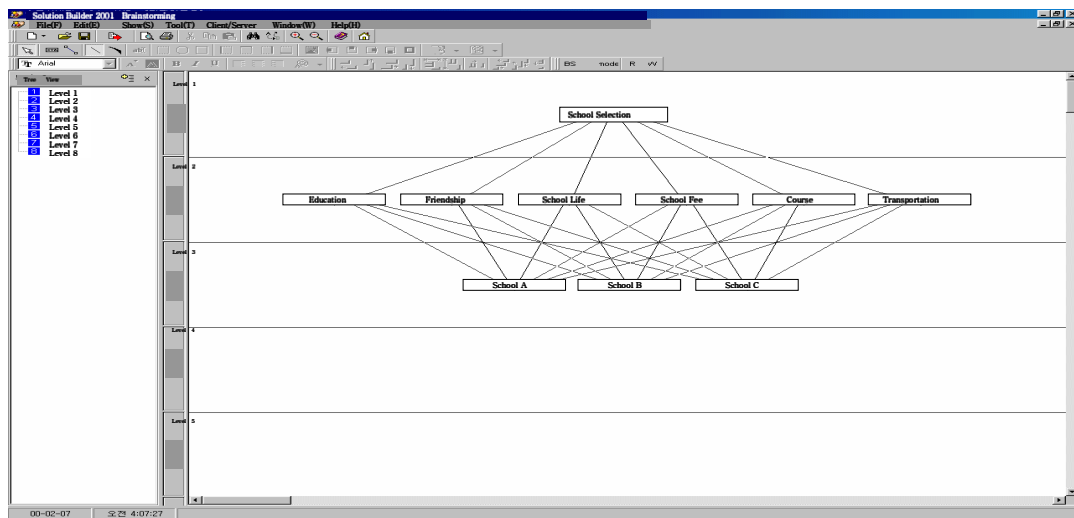Figure 4. Client and Server in Decision Support System

Figure 5. Decision Structure and Alternatives Constructed by Brainstorming File in the Network Environment (Example)
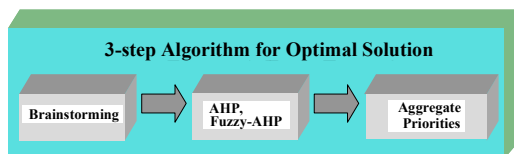

Figure 3. 3-step approach of Decision Support System

To construct decision structure and derive out the evaluation alternatives can be well determines by the group decision and the creative ideas of alternatives. For decision support system analysis of various groups, we used a brainstorming method and have developed a GUI-type program for users to use this method at an intranet/internet. To create the ideas of project evaluation alternatives and methods for decision support system analysis, we construct a decision structure using the brainstorming file in the internet/intranet–based environment without any

2.1 Individual Project Alternative Evaluation Using AHP

For the performance evaluation of decision alternatives, we used a multi-echelon and multi-attribute analysis method: AHP and fuzzy set priority method (Zahedi 1986). It is performed by 4 steps as following: 1) constructing a hierarchical structure, 2) making pair-wise matrix of decision factors, 3) computing the weighted value, and 4) consistency analysis. Figure 5 shows a sample output of alternative generation for a new school project and construct the decision structure using brainstorming results through an internet/intranet. For each level of structure we find the eigen value by a pair-wise comparison matrix based on Saaty's (1981) 9 point grading. Table 1 shows a sample output pair-wise matrix of sample problem.

Table 1. Sample output of a pair-wise matrix

Education	School A	School B	School C	Eigen-Value
Level: 2				CR = 0.046
School A	1	1/3	1/2	0.157
School B		1	3	0.594
School C			1	0.248

The final result of school planning example AHP is given by:
School B(0.378)>School A(0.367)>School C(0.254)

3. Aggregating the Results of Individual Evaluations

For integrating the results of individual evaluations, prioritized sets, we used two heuristic models; Heuristic Model 1 and Model which are a kind of majority-rule methods. These methods are compared to determine the most preferred one for the decision support system purpose.

3.1 Heuristic 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 5 evaluators and 3 alternatives is given as:

Table 2. Example Result of Heuristic Method 1

Alternative	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 1 Rank Order	C > B > A				

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

In this method, the preference matrix is 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. 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 has a limited capability to study the fuzzy set priority that could be obtained from the summed frequency matrix of Heuristic Model 2. The fuzzy matrix complement cell values sum to 1 and fuzzy set difference matrix is defined as follows:

R-RT = U(A, B) - (B, A), if   U(A, B) > U(B, A),
   =   0, otherwise

where, for U(A, B) quantifies, A is preferable to B.
To obtain fuzzy preferences, the 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(A, B)-U(B, A), if U(A, B) > U(B, A),
      = 0, otherwise
   where, for U(A, 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. Comparing the above

Heuristic Methods, we have chosen Heuristic Model 2 as the most promising one and demonstrated it as a preferred method for this example evaluation with the fuzzy set priority method. The sample problem result by fuzzy set priority method is given by:

C (0.492) > B (0.387) > A (0.121).

4. Risk Analysis Model

4.1 Stochastic Network Simulation Method

With the advent of the large cost overruns and schedule slippages on many kinds of development projects in the government sector, project managers available at that time lay in aggregation of a total risk profile. In this study, stochastic networks are characterized by their events (nodes) and activities (arcs). In this study, we used a stochastic network simulation method which is able to integrate on an equal basis the parameters of prime importance to management: time, cost, and performance as well as
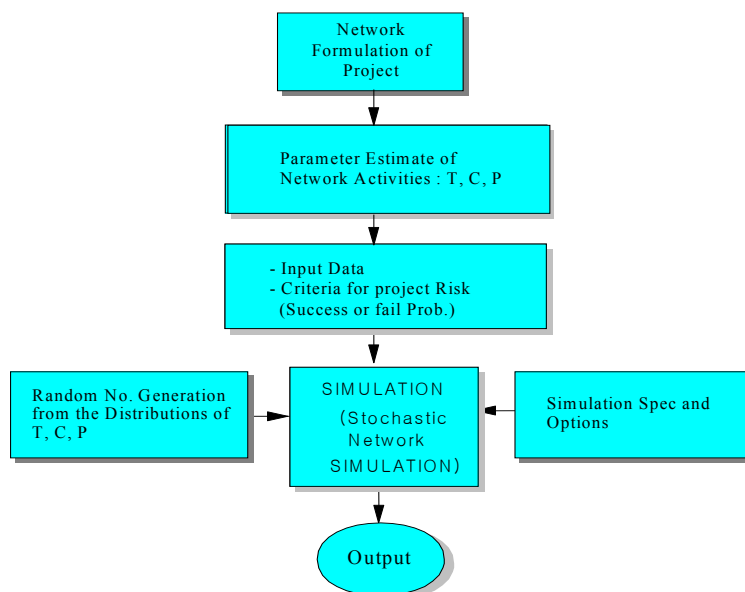
Figure 6. Schematic Structure of Stochastic Network Simulation Model

associated risks. The schematic structure of this model is shown in Figure 6.
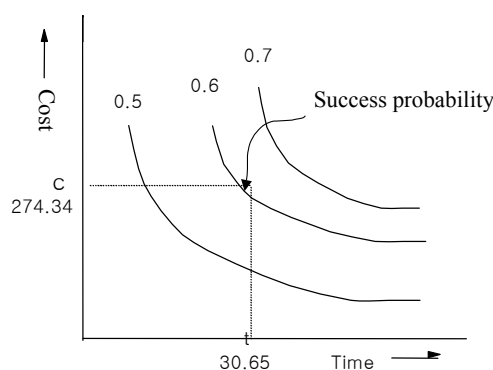

Figure 7. Sample Output for Time/Cost

realize the need for risk analysis. However, the essential difficulties in applying the techniques available at that time lay in aggregation of a total risk profile. In this study, stochastic networks are characterized by their events (nodes) and activities (arcs). In this study, we used a stochastic network simulation method which is able to integrate on an equal basis the parameters of prime importance to management: time, cost, and performance as well as associated risks. The schematic structure of this model is shown in Figure 6. Because the output options, data, and reports generated by this model are extensive and useful, there are perhaps some of the most important reasons why the technique is so useful in stochastic network analysis.

Of course, since the analyst selects the outputs to assist the manager in decision and risk analysis, only those outputs pertinent to the problem at hand and meaningful to the project managers need be selected. It should be remembered that the simulation process creates a network flow that traverses the network from initial nodes to terminal nodes and results in one trial solution or outcomes to the problem being modeled. Additionally, time/cost, time/performance, and performance/cost correlations can be graphed for all terminal nodes, including the composite terminal node. Figure 7 shows a sample output graph for time/cost.

4.2 Method Application

The example problem presented in this study is a hypothetical situation for the purpose of illustration. The project consideration of this example is a new manufacturing system development of which is in the advanced development step after successful completion of its 3 years basic research. The project block diagram is given as Figure 8. For the illustrate purpose, the following three modules of data are considered: the system control module, activity modules, and network simulation test run data. The results of sample runs are summarized in Table 3 and cost/time diagram is plotted as in Figure 9. Risk analysis model is developed to identify potential problem areas, to quantify the risks, and to generate the choice of the actions to be taken to reduce the project uncertainties.
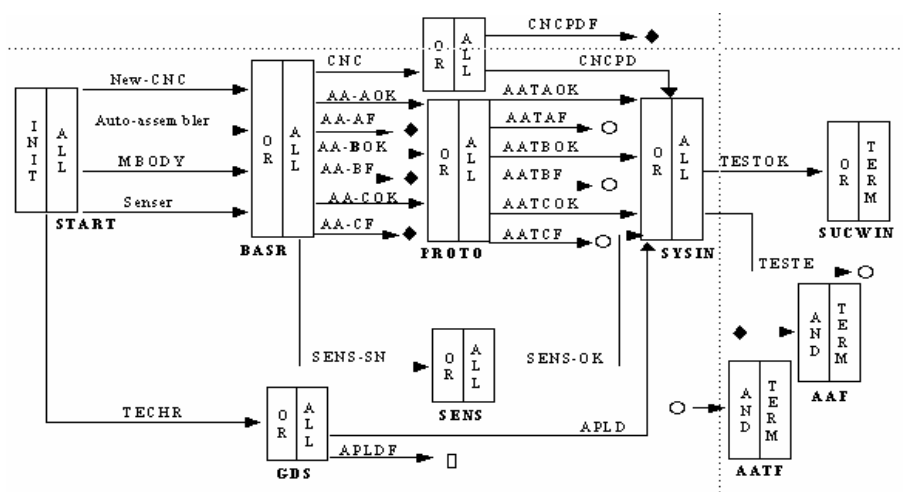
Figure 8. Project Block Diagram

Table 3. Sample Project Results

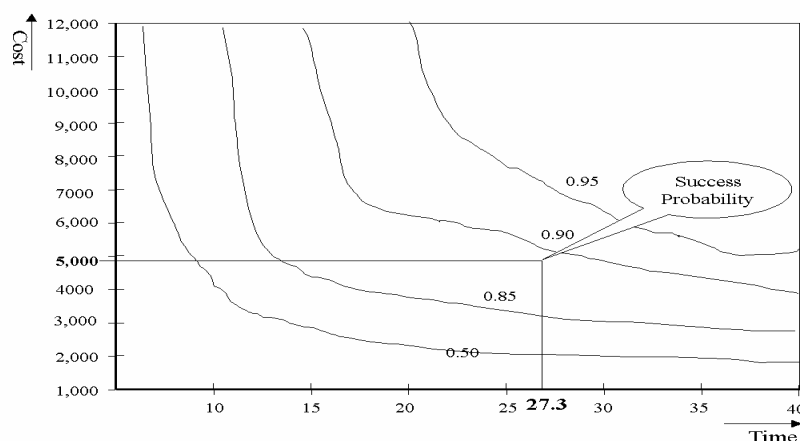| Identification	Results (unit: 10 million ₩)	Confidence
Annual Cost	1st year : 2.600 2nd year : 1.300 3rd year : 1.100 -------------------- total 5.000	89% 88% 79% -------------- 87%
Probability of Success with Time 27.3 month, Cost 5.000	88 %	To increase the Success probability to 95%, Cost needed 2.000

Figure 9. Cost/Time Diagram

5. Summary and Conclusions

The objective of proposed models is to estimate the schedule, cost and performance risks. We have developed a solution builder based on an internet/intranet for 3-step decision support system in the view of multi-attribute project evaluation using brainstorming for the idea generation, analytic hierarchy process as a multi-attribute structured analysis method and aggregation logic model to integrate the results of individual analysis. In this research, a risk analysis model is developed to identify potential problem areas, to quantify the risks, and to generate the choice of the actions to be taken to reduce

the project uncertainties. Two analysis models are proposed in this study; 1) risk factor analysis model and 2) stochastic network simulation model. The proposed models will be used in the area of R&D project evaluation to reduce project risks. Also, we have developed computer programs and have shown the results of sample run for an acquisition project of manufacturing system. It is known that the proposed model is a very acceptable for project evaluation.

References

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

Fahrni, P., (1990), "An Application-Oriented Guide to R&D Project Selection and Valuation Methods," *R&D Management*, **20**(2).

Hwang, H. S., (1998), "R&D Project Evaluation Model Based on Fuzzy Set Priority", *International Journal of Computers & Industrial Engineering*, **35**(3).

Houston, D. X. Jr., (2000), *A Software Project Simulation Model for Risk Analysis Management*, PhD Dissertation, Arizona State University.

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

Ossadnik, W. and O. Lange, (1999), "AHP-based evaluation of AHP-Software," *European Journal of Operational Research*, **118**(3), 578-588.

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

Stelios H. Z., S. Anthony, W. Nicole, and D. Sandipa, (1998), "Multi-attribute decision making: A simulation comparison of select methods," *European Journal of Operational Research*, **107**(3), 507-529.

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