Prioritizing Parameters for Software Project Selection using Analytical Hierarchical Process

Barinderjit Kaur
Punjabi University Regional Centre
Mohali, Punjab

Rekha Bhatia
Punjabi University Regional Centre
Mohali, Punjab

ABSTRACT
The highest probability of success, consuming least efforts and greatest business impact are considered major factors for the selection of best software project. The project selection is often referred as a difficult and important task by companies, but correct selection is necessary to achieve the goal. Defined methods of prioritizing the project parameters are helpful to select one best project from multiple projects. To deal with this situation AHP technique can be used to prioritize parameters for software project selection. The research work outlined the objective of AHP technique and presented the relative importance of software project Parameters. Several steps to solve the problem are highlighted. At the end the result is also checked by consistency verification, to know whether the result is acceptable or not.

Keywords
Analytical Hierarchical Process, Multiple Criteria Decision Making, Software Project Selection, Decision Making, Consistency

1. INTRODUCTION
Software project is a complete procedure of software development right from gathering requirements till its maintenance. Every software project is intended to achieve a certain goal. Higher market share is the aim of every software project manufacturing company. With the rapid manufacturing of software projects, the companies are trying to gain higher market share. Successful software manufacturing company is the one which recognizes effective strategy resulting in sustainable competitive advantage. This strategy is purely based on making choices, choosing the best decision, collecting various alternatives. To implement this strategy AHP technique plays a vital role. Using AHP technique the ranking is done in the order of effectiveness of choices that meeting conflicting objectives. It would be easier and accurate that one's opinion can be expressed on two or three alternatives than simultaneously on many alternatives. AHP uses a ratio scale instead of interval scale hence comparisons are not based on units. Consistency and cross checking facility is there between different pair wise comparisons. One of the limitations of AHP is that this includes only positive reciprocal matrix. The user friendly verbal comparisons are recorded as numbers in matrix which may result in ambiguity. [1] [6] [15]

The most popular methodology is Multi Criteria Decision Making (MCDM), that can analyze several criteria's simultaneously. In today's date numerous MCDM methods have been developed, among them AHP is mostly preferred. In [2] the researchers discussed about decisions regarding the project selection. There may be situations where decisions are dependent upon multiple factors like Identification, considerations, on the analysis part and so on. Multi-criteria decision making (MCDM) is applicable where the decisions took place among multiple attributes. So MCDM is one of the much known decision making methodology for problems facing project selection.

Hierarchical model of AHP: To prioritize project parameters, a hierarchical model is designed showing the decomposition of a problem into criteria's and alternatives. This is the most important step in Decision Making Process. The whole process of prioritizing parameters is shown in fig 1. [7][10].

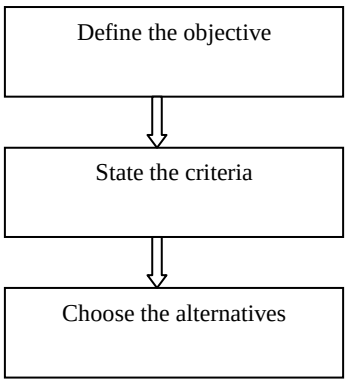

Fig 1: Steps of AHP

In [8] the researchers discussed about the use of AHP technique and MCDM to resolve the problem of selecting the appropriate GIS software package for a particular GIS project. In [14] the researcher proposed the questionnaires for pair wise comparisons of various teacher's managerial characteristics and competencies. AHP technique is used to analyze the result and it then derives the global weights from partial weights obtained as a result of pair wise comparisons.

In [3] [4] the researchers illustrate two approaches first are the total cost of ownership and second are AHP technique and also comparison between them. The most critical functions for a successful organization are supplier selection and its evaluation. Several approaches exist in the literature to objectively evaluate suppliers, including analytic hierarchy process and total cost of ownership. AHP provides a framework to cope with situations depending on multiple criteria for supplier selection, whereas the total cost of ownership is a methodology which is more than the purchasing price, to better understand and manage costs for maintaining good relationship with suppliers.

In [11] the researchers considered the project selection as an important task. While the selection of a proper project for a specified job several factors are identified. For this purpose the researchers applied the AHP technique with QFD (Quality Function Deployment). Firstly the AHP method is redefined under fuzziness. After then, customer requirements are identified and ranked by applying QFD process and are translated into product specification. Finally the sensitivity analysis has been made to create the more robust process.

Table 1. Comparison Of Above Described Papers

Sr. no	Name of Research paper	Name of Authors	Highlights
1.	Supplier evaluation and selection via Taguchi loss functions and an AHP.[5]	W.-N. Pi, C. Low	The project selection problem by using DSS method doesn't generate efficient result. It cannot handle multiple decisions simultaneously. In available DSS methods, application of the AHP to the project selection problem is not now beneficial.
2.	Decision Making in Complex Environments.[6]	T.L. Saaty	The Analytic Network Process for Decision Making with Dependence and Feedback.
3.	Interactive selection model for supplier selection process.[7]	F.T.S. Chan	Integrated the cardinal and ordinal preferences using ANP/ AHP for project selection. But their decisions are not valid. In the research paper, project selection and evaluation studies have been carried out using simple AHP method for selecting the best software project.
4.	A novel Integrated AHP-QFD model for software project selection under fuzziness.[11]	Tuli Bakshi, Bijan sarkar and Subir kumar sanyal	The AHP and QFD are integrated to establish a framework for prioritizing customer requirements by assigning integer values via comparisons and hence to reach at efficient decision for selecting a best software project.
5.	An AHP framework for prioritizing customer requirements in QFD.[10]	R.L. Armacost. P.J. Componation, M.A. Mullens, W.W. Swart	Researchers focused on the identification and prioritization of customer requirements .Integrated the AHP technique and QFD for prioritizing customer requirements.

2. PROBLEM FORMULATION

The selection of project entirely depends on the criteria that the company might not face any loss. Before the selection, first the company focuses on basic parameters, then on sub criteria's and after on alternatives. The classification is shown in fig 2. The identified criteria's are ranked by taking survey from software project companies .The identified parameters has been written in matrix form and compared with themselves in a single pair. The relative importance of each parameter is expressed over one another by numerical values. [11] [13]

Objective comes at the first level of hierarchy, which is the problem undertaken. Various criteria's are at second level of hierarchy. This study has project parameters as criteria's such as project scope, project benefits, project risks, cost of project, completion time for project, resource utilization, project management, project quality, project integration. Sub criteria's comes at third level of hierarchy. We have selected five prominent parameters from all of them.

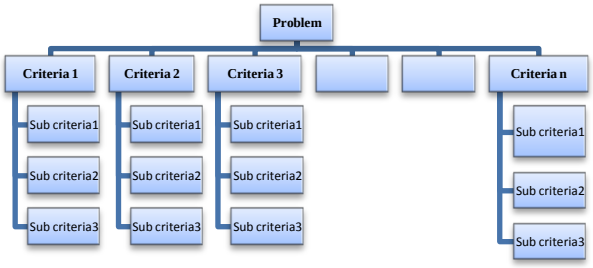

Fig 2: AHP (Detailed process)

The degree of relative importance of parameters over others could be equal, little important, much more important, far more important, absolutely more important, or intermediate. These levels of degree's are presented in table 2.This derives the priority of each parameter's over others. Based on their calculated consistency, the final decision is made [14].

Table 2. Saaty's Scale for Relative Degree of Importance

Degree of Importance	Description of each Degree
1	Equally important
3	A little more important
5	Much more important
7	Far more important
9	Absolutely more important
2,4,6,8	Intermediate values

Fig 3. Illustrates the view of five prominent parameters and these parameters (criteria's and sub criteria's) are described below:

1. PROJECT RISKS**:** These are the uncertain events which may occur in future and their probability may

or may not be defined some kinds of risks can be identified earlier but not all. There can be various risk factors which are classified as:

- Risks in planning or scheduling
- Risks in operation
- Risk in cost estimation
- Risks in technique
- Technology risks

2. PROJECT BENEFITS: A project is said to be successful if has the ability to deliver benefits.

- Increased throughput.
- Elimination of time wasting tasks.
- Lowering the level of unnecessary Resource utilization
- Improved interest and motivation among team members.

3. COST**:** This is one of the most important parameters; because every phase of project consumes money. The total cost of project includes all the direct and indirect expenditure. Economy has following classification:

- Money spent on buying Resources like on hardware, software.
- Money spent on staff for training.
- Money spent for new technology

4. RESOURCE UTILIZATION**:** A software project cannot be manufactured without using resources. Distinct Resources are needed at each phase of manufacturing the software project.

- Resources needed to manufacture
- Human Resources
- Security Resources

5. COMPLETION TIME: The manufacturing process of software project must be completed before the deadline met. So this parameter can also be considered as one of the major parameter.

- Gathering requirements
- Analysis
- Design
- Development
- Testing
- Implementation/Training

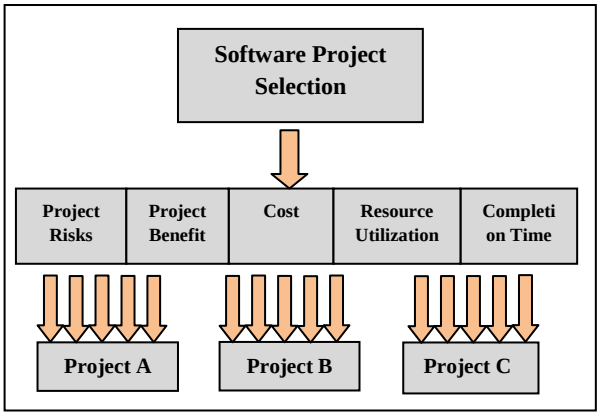

Fig: 3 Block Diagram for Detailed AHP

This type of work has not been done for prioritizing software project parameters. The study used the AHP technique in which pair wise comparison is made to determine the relative importance of each parameter. First the pair wise comparison has been done, for the parameters involved in the study and a reciprocal matrix has been developed. From that matrix, a normalized matrix has been obtained by dividing each column element by column sum. After priority vectors have been obtained by averaging each row of matrix. This method of obtaining priority vector is known as Approximation method.

In [14] Saaty has proposed a consistency index (CI), which is related to Eigen value method. The correct priorities are those which are derived from consistent or near consistent matrices. The proposed study also applied the consistency check. The consistency ratio (CR) is the ratio of CI and RI, which is given by:

$$CR = \frac{CI}{RI}$$

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Where λ_{max} = maximum Eigen value, n=order of matrix and RI= Random index (the average CI of 500 randomly filled matrices).If CR is less than 0.1 0r 10% then, the matrix is said to be having acceptable consistency. The calculated resultant consistency is 0.0804 which is less than 0.1, hence acceptable.

Table 4.Values of Random Index

Matrix Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

3. RESULTS

Experimental result of the five prominent parameters is presented in the tabular form. All the five parameters are written in a row and in a column so as to form the matrix and then the matrix get completed by filling the survey values of parameter comparisons.

Project Risk (PR), Project Benefit (PB), Cost (CO), Resource Utilization (RU), Completion Time (CT).

Table 5. Positive Reciprocal Matrix for Project Parameters

	PR	PB	CO	RU	CT
PR	1/1	3/1	1/3	5/1	3/1
PB	1/3	1/1	1/5	5/1	3/1
CO	3/1	5/1	1/1	7/1	5/1
RU	1/5	1/5	1/7	1/1	1/3
CT	1/3	1/3	1/5	3/1	1/1

The fractional values in Table5. shows the relative importance of each parameter over another and these values are collected by a survey.

Table 6. Pair Wise Comparison of Parameters

	PR	PB	CO	RU	CT
PR	1.0000	3.0000	0.3333	5.0000	3.0000
PB	0.3333	1.0000	0.2000	5.0000	3.0000
CO	3.0000	5.0000	1.0000	7.0000	5.0000
RU	0.2000	0.2000	0.1428	1.0000	0.3333
CT	0.3333	0.3333	0.2000	3.0000	1.0000
	4.8666	**9.5333**	**1.8761**	**21.0000**	**12.3333**

The fractional values are converted into decimal form up to four decimal places and column sum is obtained in table 6.

Table 7. Column Normalization

	PR	PB	CO	RU	CT	Priority Vector	Rank
PR	0.2054	0.3146	0.1776	0.2380	0.2432	**0.2357**	**2**
PB	**0.0684**	**0.1048**	**0.1066**	**0.2380**	**0.2432**	**0.1522**	**3**
CO	0.6164	0.5244	0.5330	0.3333	0.4054	**0.4825**	**1**
RU	0.0410	0.0209	0.0761	0.0476	0.0270	**0.0425**	**5**
CT	0.0684	0.0349	0.1066	0.1428	0.0810	**0.0867**	**4**
	1.0000	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	

The columns are normalized by dividing each column element by column sum, and then average of each row is calculated that gives the priority values. Hence higher the priority value more will be the importance of parameter. This is clear from Table 7. that CO is the most important parameter. PR parameter is having second most importance, while RU parameter has least relative importance.

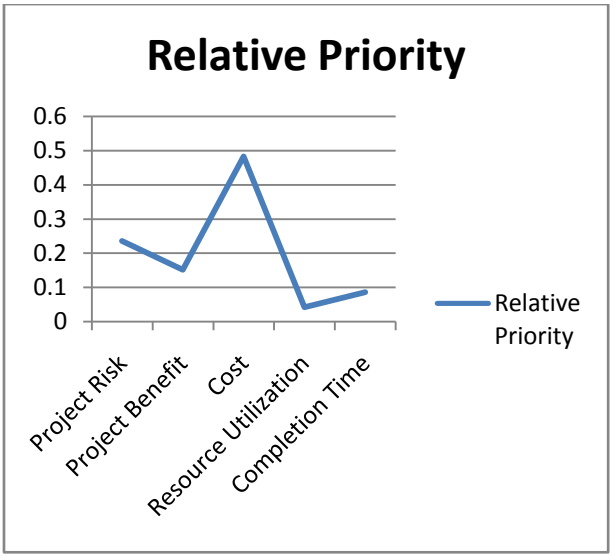

Fig. 4 Graphical Representation of Prioritized Parameters

4. CONCLUSION

The Analytical Hierarchical Process has been used to select the best project by prioritizing the project parameters [1] [6] [15]. To improve the consistency at another level Analytical Network Process (ANP) can be used but it is difficult to implement due to larger number of comparisons[7].The AHP technique has been applied on the data collected by surveying a software manufacturing company, we concluded that "Cost "has the highest priority; where as "Resource Utilization" has the least priority. This means that for a company to make a fruitful decision regarding software project selection, it should first focus on the total Cost of project and then on the profitability of the project. The "Completion time" comes at forth level of priority, whereas "Project risk" is at third level.

This whole procedure would be beneficial for the software project manufacturing companies to make the correct decision regarding the selection of appropriate software project. Further, more parameters can also be explored in this field.

5. REFERENCES

[1] Thomas.L.Saaty,"The analytic hierarchical process", MC Graw hill international in New York, 1980.

[2] C.L.Hwang & K.P.Yoon," Multiple Attribute Decision Making and Introduction", London, Sage Publication, (1995) pp2.

[3] K.S. Bhutta, F. Huq," Supplier selection problem: a comparison of the total cost of ownership and analytic hierarchy process approaches, Supply Chain Man-agreement", International Journal 7 (3) (2002) 126–135.

[4] M. Marufuzzaman, K.B. Ahsan, K. Xing," Supplier selection and evaluation method using analytical hierarchy process (AHP)", International Journal of Value Chain Management, 3 (2) (2009) 224–240.

[5] W.-N. Pi, C. Low," Supplier evaluation and selection via Taguchi loss functions and an AHP", International Journal of Advanced Manufacturing Technology, 27 (5–6) (2006) 625–630.

[6] T.L.Saaty,"Decision Making in Complex Environments", RWS Publications, Pittsburgh, PA, 2001.

[7] F.T.S. Chan,"Interactive selection model for supplier selection process", International Journal of Production Research 41 (15) (2003) 3549–3579.

[8] M.H.Elwany, A.B.Eltawil," An AHP based Decision Model for GIS software selection", Proceedings of the 37th international conference on computer and industrial engineering, October 20-23, 2007.

[9] M. Bevilacqua, F.E. Ciarapica, G. Giacchetta," A fuzzy-QFD approach to supplier selection", in Journal of Purchasing & Supply Management, 12 (2006) 14–27.

[10] R.L Arm cost, P.J. Componation, M.A. Mullen's, W.W. Swart," An AHP framework for prioritizing customer requirements in QFD", IIE Transactions ,26 (4) (1994) 72–79.

[11] Tuli Bakshi, Bijan sarkar and Subir kaumar sanyal "Anovel Integrated AHP-QFD model for software project selection under fuzziness", International journal of computer application, volume 54- No 7, September 2012.

[12] Saaty, T, "Decision-making with the AHP Why is the principal eigenvector necessary?", European Journal of Operational Research.,2003.

[13] Saaty, T,"Rank from comparisons and from ratings in the analytic hierarchy/network processes",European Journal of Operational Research,2006.

[14] Helena Brozova, "Weighting of students' preferences of teacher's competencies",Journal on Efficiency and Responsibility in Education and Science.

[15] T.L.Saaty, "Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process", Pittsburg RWS Publications, 2000.