Application Of Analytic Hierarchy Process (AHP) In The Evaluation and Selection Of an Information System Reengineering Projects

Dr Zahi Abu-Sarhan

Applied Science Privet University, CIS Department, Amman, Jordan

Summary
This paper describes an application of the Analytic Hierarchy Process (AHP) for selecting the best information system reengineering projects, the project success is the primary objective for every organization and it's may be a major problem in most of them. Organizations have to improve their efficiency and shorten their response time to markets. It is widely accepted that technological innovations are providing guidance to organizations to achieve their goals, and they most go to redesign (reengineer) the information systems and the technologies in whole organization departments, the major difficult in selecting the best project and make the right selection decision from the alternatives of information system reengineering projects which have multi criteria and every project is unique and may have success the finish or fail.

Key words:
Analytic hierarchy process, AHP, Reengineering, information system project

1. Introduction

Technological innovations are regarded as tools to help organizations strengthen their competitive advantage. Organizations information system support's their business process. However, reengineering information system created boundary to the success of technological innovations. This paper dissects the findings of a recent study on identifying the specific factors affecting the adoption of innovative processes throw reengineering current information system for realization new customer and new government needs and new system and technical and business requirements.. This study uses the Analytic Hierarchy Process (AHP) approach to prioritize the critical factors and the sub-factors of selecting information system reengineering project (ISRP). The relative weights of factors were calculated and a decision hierarchy model is suggested to support the formulation of selecting ISRP.

AHP helps to capture both subjective and objective evaluation measures, providing a useful mechanism for checking the consistency of the evaluation measures and alternatives suggested by the team thus reducing bias in decision-making.

Combined with meeting automation, organizations can minimize common pitfalls of team decision-making process, such as lack of focus, planning, participation or ownership, which ultimately are costly distractions that can prevent teams from making the right choice.

Analytical hierarchy process (AHP) is a systematic procedure for representing the elements of any problem, hierarchically [1], [2]. It recognizes the basic rationality by breaking down a problem into smaller and smaller constituent parts and then guides the decision maker through a series of pairwise comparison judgments to express the relative strength or intensity of impact of the elements in the hierarchy. The AHP is a decision-aid that can provide the decision maker (DM) with relevant information to assist the DM in choosing the "best" alternative or to rank a set of alternatives [3], [4], [5]. In this paper, an approach uses the AHP is presented in order to select the most suitable solution from the ISRP optimal set obtained by using evolutionary computations or any other approaches, based on the preference of the decision maker (DM).

The concept of information system reengineering traces its origins back to management theories developed as early as the nineteenth century. The purpose of reengineering is to "make all your information system components the best-in-class. That managers use process reengineering methods to discover the best processes for performing work, and that these processes be reengineered to optimize productivity. ISR echoes the classical belief that there is one best way to conduct tasks. In Taylor's time, technology did not allow large companies to design processes in a cross- functional or cross-departmental manner. Specialization was the state-of-theart method to improve efficiency given the technology of the time [6].

The information system reengineering (IS reengineering life-cycle) can be presents as an evolutionary process consisting of the following six stages

1. Requirements analysis: identifying the concrete reengineering goals.
2. Model capture: documenting and understanding the design of a legacy system.
3. Problem detection: identifying violations of flexibility and quality criteria.
4. Problem analysis: selecting a software structure that solves a design defect.

Manuscript received January 5, 2011
Manuscript revised January 20, 2011

5. Reorganization: selecting the optimal transformation of the legacy system.
6. Change propagation: ensuring the transition between different software versions.

2. Selecting Information system reengineering projects using AHP

The advantage of the AHP technique is that it provides a systematic approach for consolidating information about alternatives using multiple-criteria [8]. It is an objective weighing technique for setting the weighing scale for qualitative and quantitative data [1]. AHP facilitates group decision making. AHP also allows for consistency checking [9]. In other words, it allows the decision makers to check the quality of the results in the comparison matrix. Consistency is concerned with the compatibility of a matrix of the ratios constructed from a principal right eigenvector with the matrix of judgments from which it is derived. The consistency ratio is calculated for the maximum eigenvalue and is required to be less than 0.1 for acceptable consistency

A general description of the AHP process would be helpful and the steps described here will be illustrated with a real example in the next section. The first step in AHP process is to identify the overall goal or objective. In this stage you state what you are trying to accomplish and define the problem to be solved by the process and the possible outcomes.

The second step is to define or identify the criteria and sub criteria under each criterion that must be satisfied to fulfil the overall goal. Pairwise comparisons are elicited and captured into decision matrix. The relative importance of the criteria is determined using eigenvectors. The solution is obtained by raising the pairwise matrix to powers that are successively squared, then summing over the rows and normalizing to obtain the priority vector. The iteration is stopped when the difference between these sums in two consecutive calculations is smaller than a prescribed value. As the eigenvector for the pairwise comparison matrix is computed, the consistency index and consistency ratio is calculated. If the consistency ratio is greater than 0.1 the pairwise comparison matrix is checked for inconsistencies.

The third step is to pick the alternatives and to determine the preferences among these alternatives. This involves computing pairwise comparisons for the alternatives in relation to one of the identified criteria or sub criteria. The priority vectors are then computed from these pairwise comparison matrices. The priority vectors are then synthesized to obtain the overall ranking of the alternatives. To decide the relative weightings between n alternatives, it is in principle only necessary to perform n-1 assessments. By performing a complete set of full pair-wise comparisons more information than necessary is collected, but a more varied evaluation is obtained, and if one or more answers are inaccurate the other answers will compensate the inaccuracy. The number of judgments, J, that have to be made in a full pair-wise comparison can be determined by [10]:

$$J = \frac{n*(n-1)}{2} \quad (1)$$

The following is the step by step description of the procedures used to evaluate and select the ISRP.

Step 1: Requirements definition. When applying the ISR management technique to a business organization the implementation team effort is focused on the following criteria:

Processing speed (PS). Customer service oriented processes aiming to eliminate customer complaints. Dramatic compression of the time it takes to complete a task for key business processes. For instance, if process before ISR had an average cycle time 5 hours, after ISR the average cycle time should be cut down to half an hour.

Quality (QL). Obsession with the superior service and value to the customers. The level of quality is always the same controlled and monitored by the processes, and does not depend mainly on the person, who servicing the customer.

Flexibility (FL). Adaptive processes and structures to changing conditions and competition. Being closer to the customer the company can develop the awareness mechanisms to rapidly spot the weak points and adapt to new requirements of the market.

Productivity (PT). Improve drastically effectiveness and efficiency.

Reengineering Time (RT): The total required Achievement time to fish all reengineering process.

Throw the presented life cycle, in the fifth stage the manager as decision maker should select the optimal criteria for success information system reengineering project.

In order to achieve the above mentioned adjectives of the ISRP we oriented to use AHP technique to select one project of the following three.

We suggest a set of three projects they are presented in the following table 1:

Table 1: Description information system reengineering projects

Criteria / Project	PS	QL	FL	PT	RT	Cost
First Project	One Hour	Min	Middle	Min	3 months	20000$
Second Project	45 minute	Middle	Min	Middle	4 months	23000$
Third Project	30 minute	Max	Max	Max	6 months	25000$

Step 2: Creating the hierarchy. Building the hierarchy is often the most challenging of the four main steps in the AHP. Creating the hierarchy requires an intuitive feel for the various factors and sub factors that directly influence the overall goal as well as an ability to identify alternatives suitable for accomplishing the goal. The hierarchy must be designed so that these alternatives are accurately evaluated on their ability to satisfy the overall goal. Both of these tasks require the DM to be extremely knowledgeable and familiar with all facets of the problem.

The hierarchy starts at the top by clearly stating the goal of the problem. Directly beneath this goal are the primary criteria to be considered when making the decision. In Figure 1, we see that the overall goal is listed at the top of the hierarchy and is broken down into three key criteria that directly influence the goal above them.

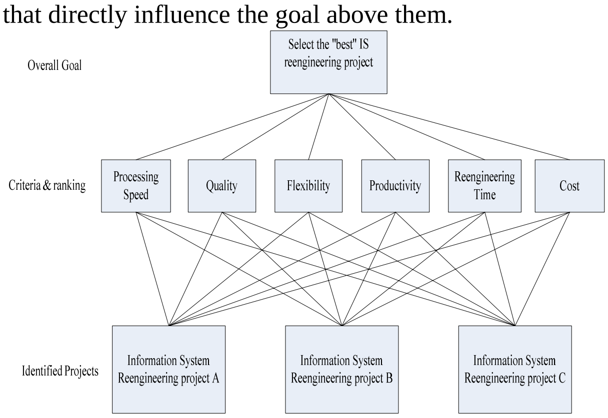

Figure 1: Hierarchy of criteria and information system reengineering projects

Step 3: Using AHP to determine the relative importance of the criteria.

To evaluate the alternatives using AHP we most use the Fundamental Scale as shown in table 2 [3].

The usage of above scales in a questionnaire is shown in Figure 2. Each paired criteria (C1 and C2) is tested with 17 options. [7]

C1	9	8	7	6	5	4	.....	4	5	6	7	8	9	C2

Figure 2. Pairwise Comparison Model

Using AHP to determine the relative importance of the criteria. Using pairwise comparisons, the relative importance of one criterion over another was computed. A total number of six pairwise comparisons were made to calculate the AHP's eigenvector values and these are shown in table 3. The result in Table 3 shows that the functionality attributes is the most preferred criterion and cost issues is the least preferred criterion. Pairwise comparisons were also computed for the sub criteria to determine the relative importance of the sub criteria relative to the criteria. These are presented later in the paper.

Table 2: AHP fundamental scales

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgement slightly favour one activity over another
5	Strong Importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme Importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent scale values	Compromise is needed between two levels
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared to j, then j has the reciprocal value when compared with I	A reasonable assumption

Table 1: Relative importance of criteria

Criteria	PS	QL	FL	PT	RT	Cost	$v_{f_{ij}}$
PS	1	8	7	9	6	8	0.544
QL	1/8	1	3	4	7	5	0.195
FL	1/7	1/3	1	3	5	4	0.120
PT	1/9	1/4	1/3	1	3	3	0.066
RT	1/6	1/7	1/5	1/3	1	3	0.041
Cost	1/8	1/5	1/4	1/3	1/3	1	0.030
Total	1.6706349	9.9261	11.783	17.67	22.333	24	1

Were $\nu_{f_{ij}}$ - The eigenvector of the relative importance

$$\nu_{f_{ij}} = \alpha_{f_{ij}} / \sum_{i=1}^{m} \alpha_{f_{ij}} \; ; \; j = \overline{1,m} \qquad (2)$$

Her $\nu_{f_{ij}}$ - eigenvector of the relative importance,

$\alpha_{f_{ij}}$ - importance sub criteria *I* with sub criteria *J*.

$$\nu_{f_{ij}} = 1/\left(1/8+1/7+1/9+1/6+1/8\right) = 0.544 \quad .$$

Similarly, the eigenvector of the relative importance contributions (i.e., weights) among three alternatives towards the six criteria are computed below in the following tables 4,5,6,7,8,9.

Table 4: The relative importance of the sub criteria relative to the criteria (Processing Speed)

PS	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	1/7	1/9	0.545
Reengineering project B	7	1	3	0.056
Reengineering project C	9	1/3	1	0.620
Total	17.0	1.4	4.1	

Table 5: The relative importance of the sub criteria relative to the criteria (Quality)

QL	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	5	4	0.69
Reengineering project B	1/5	1	2	0.19
Reengineering project C	1/4	1/2	1	0.13
Total	1.45	6.50	7.00	

Table 6: The relative importance of the sub criteria relative to the criteria (Flexibility)

FL	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	1/9	1/5	0.0593
Reengineering project B	9	1	1/8	0.2194
Reengineering project C	5	8	1	0.7213
Total	15.00	9.11	1.32	

Table 7: The relative importance of the sub criteria relative to the criteria (Productivity)

PT	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	7	6	0.7603
Reengineering project B	1/7	1	2	0.1440
Reengineering project C	1/6	1/2	1	0.0955
Total	1.31	8.50	9.00	

Table 8: The relative importance of the sub criteria relative to the criteria (Reengineering project Time)

RT	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	8	5	0.7510
Reengineering project B	1/8	1	1/2	0.0871
Reengineering project C	1/5	2	1	0.1618
Total	1.32	11.00	6.50	

Table 9: The relative importance of the sub criteria relative to the criteria (Cost)

Cost	Reengineering project A	Reengineering project B	Reengineering project C	$\nu_{f_{ij}}$
Reengineering project A	1	5	9	0.7282
Reengineering project B	1/5	1	6	0.2175
Reengineering project C	1/9	1/6	1	0.0541
Total	1.31	6.16	16.00	

The end results using AHP process are shown in table 10. The table shows that the reengineering project B is the recommended project for reengineering the information system. It can be noted from this table that although the reengineering project C scored highly regarding processing speed and flexibility issues it did not emerge as the winning project because according to the organization processing speed and flexibility issues had low priority compared to quality and productivity issues.

Table 10: Results of evaluation exercise

Alternatives	Attributes						Alternative Priority Weights
	PS	QL	FL	PT	RT	Cost	
	Attribute Weights						
	0.235	0.096	0.059	0.033	0.020	0.014	
Reengineering project A	0.545	0.69	0.0593	0.7603	0.7510	0.7282	0.2766
Reengineering project B	0.056	0.19	0.2194	0.1440	0.0871	0.2175	0.4203
Reengineering project C	0.620	0.13	0.7213	0.0955	0.1618	0.0541	0.3030

3. Discussion

It can be observed from the results of this study that, quality, productivity and cost were the most critical sub-factors that affecting the selecting of information system reengineering project of organizations. Therefore, in order to strengthen the competitive advantage of organizations, management teams of organizations should change their employees' attitudes towards learning.

The study found that organizations are usually form project teams for particular projects with members from different departments. The team members have agreed on common goals and are working collectively to achieve the goals. Small to medium enterprises (SMEs) are usually use project-based work groups to handle specific projects though many big organizations also use this strategy. It is understandable that SMEs are operating with limited resources. They have little direct control over their business environment and lack in size, adequate resources and market power [11]. They cannot afford to operate departments just for research and development. Therefore, when they received special requirements from customers and/or wanted to carry out a change in their organizations, they will form special task forces. The task forces will work on assigned missions and will dissolve upon the completion of projects. As stated by a participant of this study, the organization selects experts from various departments to form a project team to reengineering the system to fulfill the new business and government requirements.

Moreover, many participants of this study have put emphasis on organization slack though it is the least processing speed in comparing to the productivity and the flexibility. They have pointed out during the interview sessions that, slack is necessary to support the productivity. The results support an argument of a past studies that organization productivity is a key factor that affecting the adoptions of innovations. It is an important resource to enable an organization to react to internal demands and external demands [12]. Only project with sufficient slack will have change to success [13].

Conclusion

The AHP is a versatile decision aid which can handle problems involving both multiple objectives and uncertainty. It is popular with many decision makers who find the questions it poses easy to answer and the Expert Choice software user friendly. Its applications have moreover led to a huge number of published papers [14].

Nevertheless, the method has also attracted much controversy from people who have questioned its underlying axioms and the extend to which the questions which it poses can lead to meaningful responses from decision makers. Indeed, it has been argued that the apparent simplicity of the questions belies a lack of clarity in their definition and may lead to superficial and erroneous judgments. Critics have also questioned the extend to which an AHP model can faithfully represent a decision maker's preferences given the numerical representations of these judgments and the mathematical processes which are applied to them.

The AHP used to select the best information system reengineering project, the results shown in table 10 presents the eigenvectors values from which the decision makers should select the correct information system reengineering project. The decision makers select the alternative with the high value of eigenvectors.

It should, however, not be forgotten that the purpose of any decision aid is to provide insights and understanding, rather than to prescribe a "correct" solution. Often the process of attempting to structure the problem is more useful in achieving these aims than the numeric output of the model. Nevertheless this process is still best served when the analytic method poses unambiguous questions and bases its suggested solutions on testable axioms and an accurate translation of the decision maker's judgments [15]. Whether the AHP is the best technique to support this process is a question which is bound to continue to attract debate and controversy

The review exercise also indicates that the AHP is a useful decision tool to consolidate evaluation data. It provides for consistency checking. However, as the results suggests AHP should be used in combination with other decision tools to support because AHP only efficient when the number of criteria and alternative are few. Furthermore, AHP needs a software tool to assist in the tedious calculation of the eigenvectors values from the pairwise comparisons.

Acknowledgments

This work was supported by the Applied Science University, Amman, Jordan.

References

[1] Saaty, T.L., 1990. The Analytic Hierarchy Process. New York, McGraw Hill.
[2] Saaty, T.L., 1994. Fundamentals of Decision making and priority theory with the Analytic Hierarchy Process. RWS Publications: Pittsburgh.
[3] Saaty Thomas L., Vargas Luis G., 2001. Models, Methods, Concepts & Applications of the Analytic Hierarchy Process. Springer, ISBN-13: 9780792372677, ISBN: 0792372670
[4] Saaty, T.L, 2000. Fundamentals of Decision Making and Priority Theory. 2nd ed. Pittsburgh, PA: RWS Publications.
[5] Ghodsypour, S.H. and C. O'Brien, 1998. A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. Int. J. Prod. Econ., 56: 199-212.
[6] Lloyd, Tom, Giant with Feet of Clay/ Tom Lloyd Offers a Contrasting View of Business Process Reengineering, Financial Times, December 5, 1994; Pg. 8.
[7] Yudiyanty, Y., 2002. Pengukuran Kualitas Bangunan Pusat Perbelanjaan dengan Metode Analytical Hierarchy Process (AHP), Studi Kasus: Plasa Tunjungan dan Plasa Surabaya, Thesis, Petra Christian University, Surabaya.
[8] Kontio Jyrki, A Case Study in Applying a Systematic Method for COTS Selection, Proceedings of the 18th ICSE, IEEE Computer Society, 1996
[9] Zviran Moshe, A comprehensive Methodology for Computer Family Selection, Systems Software Journal, 22:17-26, 1993.
[10] Belton, V. & Stewart, T. J. (2002) Multi Criteria Decision Analysis – An Integrated Approach, Kluwer, pp 151-159.
[11] Mitra, Jay (2000), "Making Connections: Innovation and Collective Learning in Small Business", Education + Training, Vol. 42, No. 4/5, pp. 228-236.
[12] Ahmed, Pervaiz K. (1998), "Culture and Climate for Innovation", European Journal of Innovation Management, MCB University Press, Vol. 1, No. 1, pp. 30-43.
[13] Judge, W. Q., Fryxell, G. E. and Dooley, R. S. (1997), "The New Task of R & D, Management: Creating Goal Directed Communities for Innovation", California Management Review, Vol. 39, No. 3, Spring, pp. 72-84.
[14] Vaidya, O. S. & Kumar, S. (2006) Analytical Hierarchy Process: An overview of applications, European Journal of Operational Research 169, pp 1-29.
[15] Goodwin, P. & Wright, G. (1998) Decision Analysis for Management Judgment, Second Edition, Wiley, pp 15-53, 309-313.

Dr. Zahi A. Abu Sarhan (1974) received the M.S. and PhD degrees in Computerized Control Automated Systems and Progressive Information Technologies from Kharkiv National University of Radio Electronics, Kharkov in 1998 and 2004, respectively. During 2004-2008, he was an Assistant Professor at the Economics and Administrative science/ MIS Department at Applied Science University. Since 2008, he is an Assistant Professor at the Faculty of Information technology, Applied Science University in Jordan. His research interests include: Information system reengineering.