OBJECT ORIENTED SOFTWARE SYSTEM BASED ON AHP

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***Abstract*— In modern days as because there are multiple number of object-oriented software systems, it is a real challenge for everyone to choose single one system among so many and variety of alternatives. This is obviously a challenging task to find out the most appropriate software system. In this particular study Analytical Hierarchy Process (AHP) technique has been integrated with ISO 9126-1 and it has been applied for the purpose of selection of object oriented software system. In this process the basic features i.e. quality characteristics of ISO 9126-1 has to be identified and considered to formulate a set of rank for the object-oriented software system. To be specific the most appropriate object-oriented software system may be termed as number one rank based on its desirable features as against many other alternatives of the object-oriented software systems.**

Keywords- Object-Oriented software system; AHP; ISO 9126-1; Quality characteristics; Maintainability.

I. INTRODUCTION

Determination of the most appropriate object-oriented software system among a large number of alternatives is in fact a challenging task. In the selection process of the appropriate object-oriented software system the Analytical Hierarchy Process (AHP) technique has been applied along with ISO 9126-1. Ranking has been given in accordance with the quality and appropriateness of the software systems that are based on desirable characteristics compared to various other possible alternatives of such software systems. In this paper attempts have been made to present the technique of Analytical Hierarchy Process (AHP) basically with the idea of selecting the most appropriate object-oriented software system.

II. LITERATURE SURVEY

Analytical Hierarchy Process is basically an approach for making decisions and it involves a process of structuring multiple criteria of choice in to a hierarchy by means of assessing the relative importance of such criteria's and making comparison of alternatives for each and every criteria and thus make as well as determined an overall ranking of the alternatives [4]. AHP technique has been used for supporting the decision in information systems management [5], for estimation of function points [19], for architecture selection of ADSL modem [16], for a multi-criteria logistics-outsourcing decision making [3], to identify design requirements through agent-based simulation for personal air vehicle system [15], for tackling the uncertainty and imprecision of the service evaluation process [18], for irrigation water allocation in a small river basin [22], for the determination of relative significance factor of impact categories [14], as a decision-support system in the petroleum pipeline industry [23], in ecosystem management [7], for risk and opportunity assessment of international construction projects [8], in COTS decision-making [2], for project selection [13], to select a GIS software [17], and to translate common verbal phrases to numerical probabilities [20]. Furthermore, Koscianski and Costa [1] have used the AHP along with the ISO 9126 to build a quality evaluation framework.

This AHP technique [24] is very much helpful in analyzing the subjective as well as objective evaluation measures and it provides a useful mechanism for checking the consistency of the evaluation measures and available alternatives. It is an important tool for reducing bias in the decision making process. Moreover it is helpful in minimizing the common errors in decision making process such as lack of planning, participation and focus which are costly distractions that can prevent from making the right choice.

AHP is treated as a very useful method at any point of time when the decision making process becomes rather complex and when the decision cycle involves consideration of variety of multiple criteria and rating of those is based on a multiple-value choice. AHP technique bifurcates the overall problem into lesser important evaluation factors which plays significant part in making global decision.

The AHP technique consists of steps that can be arranged as:

1- Decomposing.
2- Weighing.
3- Evaluating.
4- Selecting.

A. ANALYTICAL HIERARCHY PROCESS (AHP)

AHP method [24] is popular and widely used in decision making application in various fields such as military analysis, business, software system, industry and others. It provides user with comprehensive and rational framework for quantifying problem elements and relating them with goal. AHP is useful technique for discriminating between competing options in the light range of objectives to be met. The main advantage of AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. The strength of AHP is its ability to detect inconsistent judgements. The limitations of the AHP are that it only works because the matrices are all of the same mathematical form – known as positive reciprocal matrix [6].

AHP method [24] is used to determine the weight matrix. The AHP process is initially proposed by Saaty uses multi-criteria decision making methods. Consider n factors to be compared $C_{1,}$ $C_{2,........,}$Cn and denote the relative weight of C_i and C_j as a_{ij} and square matrix A= $[a_{ij}]$ of order n. For matrix involving human judgments, judgments are inconsistent to a greater or lesser degree. In case find vectors satisfy the equation Aw = λmax w, and λmax≥ n where w is eigen vector and λmax represents eigen values. The difference between λmax and n is indication of inconsistent of the judgments. Saaty proposed consistency index (CI) and consistency ratio (CR) to verify the consistency of the comparison matrix. These are defined as:-

CI= λmax-n/ (n-1);

CR= CI/RI

Where, RI is average index over numerous random entries of the same order reciprocal matrices. Saaty suggests that if the CR exceeds 0.1, the set of judgment may be too inconsistent. In such case a new matrix is required to prepare until CR≤0.1

B. APPLICATION OF ISO 9126-1 IN SELECTION PROCESS

In this study the International Standard like ISO 9126-1 [9] has been applied in the process of selection and this standard has been framed with six quality characteristics for international and external software products further, it contains a set of other characteristics that may be applied to the software product quality in use. ISO 9126-1 [9] hierarchical software quality model with six major quality characteristics. These quality characteristics are divided into 21 sub-characteristics which contribute to internal quality. This model is a generic model. The external software product quality characteristics are considered as a criteria for selection of object-oriented software system that may be used against other available alternatives. The external software product quality characteristics (selection criteria) that may be used are as follows :-

1- Functionality (F).
2- Reliability (R).
3- Usability (U).
4- Efficiency (E).
5- Maintainability (M).
6- Portability (P).

There are another three additional standards in addition to this ISO 9126-1 e.g.:

1- ISO 9126-2 on external quality metrics [10],
2- ISO 9126-3 on internal quality metrics [11],
3- and ISO 9126-4on quality in use metrics [12].

However each of them having a set of software quality metrics related to each of the above six quality characteristics. As such for measuring any of these six quality characteristics a set of related quality measures has to be calculated first and then it should be converted to a percentage value in order to represent the corresponding quality characteristics [21].

III. PROPOSED METHODOLOGY

In order to get ranking of the alternative object-oriented software system the following steps are to be followed:

1- Selection of the criteria (quality characteristics of ISO 9126-1) that is to be applied.

2- Determination of the relative importance of the selected criteria.

3- Building a matrix of the relative importance.

4- Square the matrix.

5- Compute the eigenvector viz:

a. Sum the rows.

b. Sum the row totals.

c. Divide the row sum by the row totals.

d. The result is the eigenvector.

6- If the eigenvector does not change from the previous iteration then next step has to be followed, otherwise Step 4.

7- Identification of a set of alternative object-oriented software system as required.

8- Collecting the related software metrics based on ISO 9126-2 (external metrics) for each of the selected characteristic.

9- Computing the corresponding software metrics for each criterion.

10- Converting the result to a percentage value for each criteria.

11- Determining the reference of each alternative object-oriented software system over another based on percentage value of each criteria in terms of criteria (Quality Characteristics).

12- Computing the eigenvector to determine the relative ranking of alternative object-oriented software system under the selected criteria.

13- Building a matrix of the eigenvectors of the relative ranking of each alternative object-oriented software system under each criterion.

14- Multiplying the matrix of the alternative object-oriented software system eigenvectors by the criteria eigenvector, the result is the ranking of the alternative object-oriented software system.

IV. CASE STUDY

Suppose that we have five alternative object-oriented software systems to choose from, and we have selected the following three quality characteristics to be the selection criteria for the alternative object-oriented software system:

1- Reliability (Rb).

2- Usability (Ub).

3- Maintainability (Mb).

At the beginning, we need to determine the importance of the selected criteria, see formula (1). For example, the Usability is 2 times as important as Reliability, whereas, the maintainability is 3 times as important as Usability. Formula (2) shows the same contents of formula (1) but after converting them to four decimal values.

$$A = \begin{array}{c|ccc|} & \mathbf{Rb} & \mathbf{Ub} & \mathbf{Mb} \\ \hline \mathbf{Rb} & 1 & 2/1 & 1/2 \\ \mathbf{Ub} & 1/2 & 1 & 1/3 \\ \mathbf{Mb} & 2/1 & 3/1 & 1 \\ \hline \end{array} \quad (1)$$

$$A = \begin{array}{c|ccc|} & \mathbf{Rb} & \mathbf{Ub} & \mathbf{Mb} \\ \hline \mathbf{Rb} & 1.0000 & 2.0000 & 0.5000 \\ \mathbf{Ub} & 0.5000 & 1.0000 & 0.3333 \\ \mathbf{Mb} & 2.0000 & 3.0000 & 1.0000 \\ \hline \end{array} \quad (2)$$

Now, we have to square (*A**A*) the matrix in formula (2), the results are shown in formula (3) below.

$$B = \begin{array}{c} \\ Rb \\ Ub \\ Mb \end{array} \begin{array}{c} \begin{array}{ccc} Rb & Ub & Mb \end{array} \\ \begin{bmatrix} 3.0000 & 5.5000 & 1.6666 \\ 1.6666 & 2.9999 & 0.9166 \\ 5.5000 & 10.0000 & 2.9999 \end{bmatrix} \end{array} \quad (3)$$

Now, let's compute the first eigenvector, that is, sum the rows (for example, the summation of the first row is 10.1666), sum the row totals (34.2496), and finally divide the row sum by the row totals, as in formula (4).

$$C = \begin{array}{cc} 10.1666 & 0.2968 \\ 5.5831 & 0.1630 \\ 18.4999 & 0.5401 \\ \hline 34.2496 & 1.0000 \end{array} \quad (4)$$

The above process (computing the eigenvector) must be iterated until the eigenvector solution does not change from the previous iteration. However, the result of the above formula is the eigenvectors, as shown in Table 1.

TABLE I. THE FIRST EIGHEN VECTOR

Rb	0.2968
Ub	0.1630
Mb	0.5401

The second eigenvector have been computed by squaring the formula (3). The second eigenvector is shown in Table 2. Anyway, we will stop the process of computing the eigenvector since the two eigenvectors are close to each other.

TABLE II. THE SECOND EIGHEN VECTOR

Rb	0.2969
Ub	0.1634
Mb	0.5396

From the above table, we can note that the Maintainability is the most important criterion, the Reliability is the second most important criterion, and the Usability is the least important criterion.

Now, suppose that we have collected and computed the related external metrics of the selected quality characteristics (Reliability, Usability, and Maintainability) for each of the five object-oriented software systems, and then we have converted them to percentage values, as in Table 3 below.

TABLE III. THE PERCENTAGE VALUES OF THE SELECTED CRITERIA (QUALITY CHARACTERSITICS)

	Rb	***Ub***	***Mb***
P1	0.4378	0.6789	0.1272
P2	0.7598	0.5812	0.7836
P3	0.5436	0.2383	0.8742
P4	0.6762	0.9135	0.9232
P5	0.8976	0.3465	0.7401

Finally, we need to multiply the matrix of Table 3 by the eigenvector of Table 2; this multiplication will give us the ranking of the 5 alternative object-oriented software systems. The results are shown in Table 4 below.

TABLE IV. THE MULTIPLICATION OF TABLE 3 BY TABLE 2

P1	0.3069
P2	0.7435
P3	0.6721
P4	0.8482
P5	0.72225

From Table 4, we can note that the P4 is the most appropriate one based on the 3 quality characteristics; the P2 is the second most appropriate one, and so on. In more details, Table 5 shows the ranking of the five object-oriented software systems.

TABLE V. THE RANKING OF OBJECT-ORIENTED SOFTWARE SYSTEMS

OO Software systems	Rankings
P1	5
P2	2
P3	4
P4	1
P5	3

V. CONCLUSION

We may conclude by stating that AHP technique and ISO 9126-1 quality model have been integrated and applied to the selection process of the object-oriented software system. The basic features (i.e. the ISO 9126-1 quality characteristics) are required to be identified and taken into consideration to formulate a set of ranks for the required object-oriented software system on the basis of its appropriateness (e.g. “rank one” for most appropriate object-oriented software system) to the quality characteristics against the other alternatives of object-oriented software system. Further, in order to apply the proposed approach in this study, the external matrix for each of the alternative object-oriented software system in which any one needs to make a specific choice.

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