Requirements Prioritization Based on Goals' Weights

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ABSTRACT

Most, if not all, of the software projects developed can't implement the entire requirements within a given time and available resources. Hence Requirements Prioritization (RP) is needed to define the priorities given the available resources and constraints. It could be claimed that the RP process represents the heart of software systems development, as failure in choosing the right requirements during the requirements elicitation phase, or for release planning, could have the projects challenged or fail. There are many prioritization techniques available in the literature for prioritizing software requirements. However, most of them work well on a small number of requirements, but when the number of requirements and stakeholders' preferences increase, many of these techniques suffer from different shortcomings, such as scalability, uncertainty, time consumption, and complexity. In addition, most of these techniques don't take into consideration the effects of a project's required goals on the final alternatives' ranking. In this paper, we propose another RP technique based on goals' weights to reduce the problems of time consumption, scalability and complexity. We evaluate our RP technique through case studies and compare results with other available RP techniques. In this paper we present the results of comparision with Fuzzy Analytical Hierarchy Process (FAHP).

Keywords: goals' weights, requirements engineering, requirements prioritization.

1- INTRODUCTION

Requirements prioritization (RP) is generally defined as the activity, carried out during requirements elicitation, during which the most important requirements for a software system can be discovered [1]. Firesmith [2] states that RP could be defined to be the process to determine the:

- order of importance of the requirements to the stakeholders, or
- implementation order of the requirements for implementing a software

system.

It is a well-known fact that the number of software requirements usually exceeds the number of features that can be implemented within a given time and available resources. Hence RP is needed to define the priorities given the available resources and constraints. Most, if not all, of the software projects developed can't implement the entire requirements within a given time and available resources. Failure in choosing the right requirements during the requirements elicitation phase, or for release planning, could have the software projects challenged or fail. The big failure that happened to the FBI project in 2005 [3], with a loss of 170 million dollars, is one example. The project's requirements document was about 800 pages. Researchers mentioned that one of the main failure reasons was RP [4], [5]. Hence It could be claimed that RP represents the heart of software systems development. According to Brooks [6] "[t]he hardest single part of building a software system is deciding what to build …. No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later". Figure 1 gives an illustration of the context of RP within the requirements engineering (RE) and software engineering disciplines.

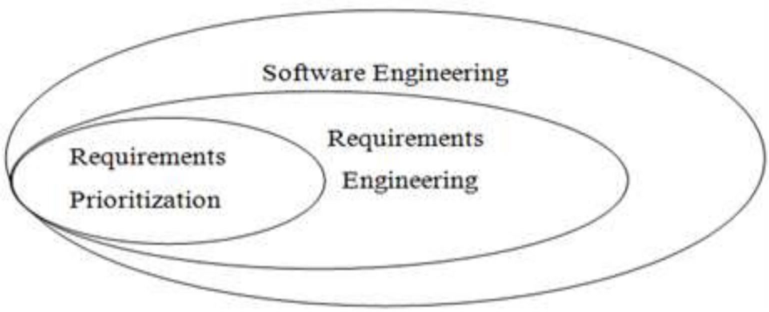

Figure 1 RP context in relation to RE and software engineering.

Among the additional benefits of RP are [4], [5], [7]:

- Helping the stakeholders to resolve conflicts, which are usually due to multiple stakeholders' views, e.g. [8]:
  - A sales manager would be interested in the market directions.
  - A financial manager would be interested in a project's cost.
  - An operational manager would be concerned with a system's performance.
  - An end user would be concerned with a system's interface.
- Balancing the business benefit of each requirement according to its weight factors.
- Estimating expected customer satisfaction.
- Establishing relative importance of each requirement to provide the greatest value at the lowest cost.

There are many prioritization techniques available in the literature for prioritizing software requirements. We highlight the most popular ones in Section 2 of this paper. However, according to more than one study, e.g. [9], most of the RP techniques work well on a small number of requirements, but when the number of requirements and stakeholders' preferences increase, many of these techniques suffer from different shortcomings such as scalability, uncertainty, time consumption, and complexity. According to many studies, e.g. [7], [10], [11] none of the prioritization techniques can be considered the best; the best prioritization technique usually depends on the situation. There is even no standard criteria for evaluating an RP technique, and that is why researchers attempting to conduct RP techniques' evaluations reach conflicting results, e.g. [9], [12].

One of the most popular definitions for RE is that it is a branch of software engineering concerned with the real-world goals, functions of, and constraints on software systems [10]. So, it could be claimed that all of the RE activities are used to ultimately serve the goals identified by the stakeholders. In spite of that, most of the RP techniques don't take into account the effects of the required goals on the final alternatives' ranking. We propose a new RP technique based on goals' weights derived from hybrid prioritiztion techniques in an attempt to enhance reported problems of time consumption, scalability and complexity.

the organization of this paper as follows. Section 2 presents study of the more familiar prioritization techniques in the literature and their deficiencies. Section 3 gives a brief overview about goals. Section 4 provide a description of our proposed new RP technique based on goals' weights. Section 5 presents an evaluation framework and case study is used for evaluating our proposed RP technique. Finally, Section 6 gives the conclusion and future work.

2- PRIORITIZATION TECHNIQUES

According to the Chaos Manifesto 2011 [13], the projects evaluation results showed that 37% of projects are delivered on time and budget, 42% challenged and 21% failed. The Chaos report argues that one of the reasons for the projects failing is decision-making, which it is the biggest reason for increased cost and time. RP is a decision making problem that needs Multi Criteria Decision Making (MCDM) solutions. MCDM solutions are concerned with how to choose the best decision from different alternatives according to different criteria, which usually conflict. The basic idea for most RP techniques belongs to the scoring methods. The scoring methods are compensatory methods that generate relaive weights for the requirements. So the requirements importance can be measured and ranked according to specific criteria with different scales. These scales have advantages and disadvantages. In this section we give an overview of the three basic types of measurement scales that are used widely in RP techniques; these types are nominal, ordinal and ratio scales [14], [15]. We will present the most famous techniques for RP within each type, highlighting the advantages and limitations of each technique.

2-1 NOMINAL SCALE

In this type of scale, data is classified into categories and cannot be arranged in any particular order. The methods that belong to this scale can create different groups without any order for ranking as the group of colors, where each group is assigned a different priority; the requirements are assigned to these groups according its priority. One of RP methods that apply this scale is a Numerical Assignment (Grouping) technique. This technique divides the requirements into three groups: Critical, standard, and optional. The worst problem in this technique is that there are no differences in priority within each group, but this technique is considered very easy and scalable [14].

2-2 ORDINAL SCALE

In this type of scale, data is arranged in some order, but the differences between data values cannot be determined or meaningless. The methods that belong to this scale can create different groups with the order meaning as the group of favorite drinks (1- tea, 2- coffee, 3- milk, etc.). So its techniques can support ranking, such as simple ranking, bubble sort and Binary Priority List (BPL) [7], [15]. BPL is an important technique that uses ordinal scale which its idea depends on comparison and ranking horizontal or vertical. We put any requirement into the first level then compare it with the next requirement. If it is more important put it up or if it is a low important put it down and so on for all requirements. According to Bebensee et al. [16], [17], the result is ranked requirements, as shown in Figure 2. PBL technique is easy and reliable but it suffers from scalability issues especially for large requirements. Besides BPL technique does not take into account the dependencies between requirements.

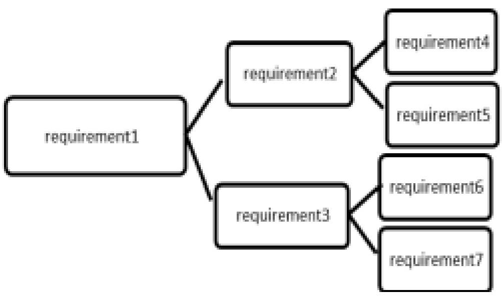

Figure 2 PBL architecture.

2-3 RATIO SCALE

In this type of scale, data can be ranked and differences, relative ratios are meaningful for this level of measurement. The methods that belong to this scale can create different groups, with the order meaning and provide the relative difference between requirements such as methods in the following sub-sections.

2-4 CUMULATIVE VOTING (CV) - THE $100 TEST

The idea of the $100 technique is that each stakeholder is asked to assume s/he has $100 to distribute among the requirements [12], [18]. The result is presented on a ratio scale. The $100 test is a very straightforward prioritization technique. A problem with this technique arises when there are too many requirements to prioritize. Another possible problem with the $100 test (especially when there are many requirements) is that the person performing the prioritization miscalculates the points, and they do not add up to 100. This can be prevented by using a tool that keeps count of how many points have been used. The risk with such an approach is that stakeholders may be forced to not prioritize according to their actual priorities [19], [20].

2-5 HIERARCHICAL CUMULATIVE VOTING (HCV)

The idea of HCV is like CV, but is classified into different levels of hierarchies. HCV was developed in an attempt to address the scalability issues in CV, as shown in Figure 3 that illustrates the technique; it shows that in the high level there are a three groups (G1, G2, and G3). According to CV technique we must distribute $100 between the three groups. In the next level, for group 1 which contain two requirements we must distribute another $100 between the two requirements and so on for every group. Although HCV technique had present a good solution for scalability issue. However, when the no of requirements in the high level or its sublevel is exceeds. We need more levels to keep on the scalability that is causing a more time consuming [19].

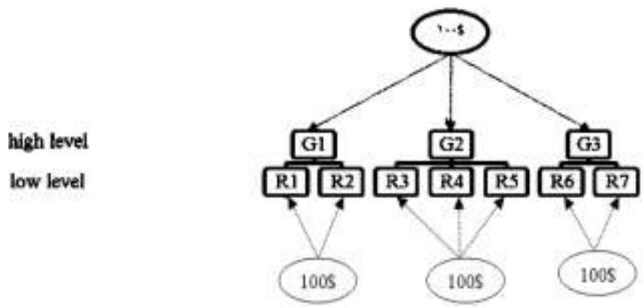

Figure 3 HCV.

2-6 ANALYTICAL HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP), is introduced by Thomas Saaty in 1980 to help the decision maker for best choice from alternatives with ranked relative weights. The idea that satty introduced is a pairwise comparison between all possible alternative pairs according to its criteria. Satty presented a measure scale to measure the relative importance between every alternatives pairs as shown in Table 1. Then design the weight matrix which result the ranked alternatives weights depending on calculation of eigenvector and eigenvalue [21]-[23]. However, AHP suffers from time consuming, scalability, redundancy, uncertainty, vagueness and inconsistency issues.

Table 1 Saaty rating scale

Values	Definition	Explanation
1	Equal importance	Two factors equally importance to the objective
3	Somewhat more important	Experience and judgment slightly favor over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Absolutely more Important.	The evidence favoring one over the other is of the High-est possible validity.
2,4,6,8	Intermediate values	When compromise is needed

2-7 FUZZY ANALYTICAL HIERARCHY PROCESS (FAHP)

To overcome the issues for AHP results, especially the requirements vagueness and uncertainty. FAHP was introduced based on the concepts of fuzzy sets theory developed by Zadeh [24]. Using the fuzzy numbers for calculating the relative weights instead of the real numbers, that are used in classical AHP technique [24], [25]. Besides the basic idea of AHP technique that is based on pairwise comparison, the FAHP built it algorithm as same as AHP classical technique and the fuzzy set advantages. The algorithm of FAHP technique can be summarized into the following steps [26]:

1. Decision Maker introduce the decision matrix to identify the criteria weights based on the linguistic terms scales that introduced through the linguistic variables, which are represented by triangular numbers [25] as shown in Table 2:

Table 2 Linguistic terms and corresponding triangular fuzzy numbers

Saaty scale	Definition	Fuzzy Triangular Scale
1	Equally important (Eq. Imp.)	(1, 1, 1)
3	Weakly important (W. Imp.)	(2, 3, 4)
5	Fairly important (F. Imp.)	(4, 5, 6)
7	Strongly important (S. Imp.)	(6, 7, 8)
9	Absolutely important (A. Imp.)	(9, 9, 9)
2	The intermittent values between two adjacent scales	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

2. For every criteria Design the decision matrix that determine the alternatives relative weights as following matrix

$$\begin{array}{c|c} & \begin{array}{cccc} C_1 & C_2 & C_3 & C_n \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ \\ C_n \end{array} & \begin{pmatrix} \tilde{x}_{11} & \tilde{x}_{21} & \tilde{x}_{31} & \tilde{x}_{1n} \\ 1/\tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{23} & \tilde{x}_{2n} \\ 1/\tilde{x}_{31} & 1/\tilde{x}_{23} & \tilde{x}_{33} & \tilde{x}_{3n} \\ & & & \\ 1/\tilde{x}_{1n} & 1/\tilde{x}_{2n} & 1/\tilde{x}_{3n} & \tilde{x}_{nn} \end{pmatrix} \end{array}$$

Where:

$C_1, C_2, C_3, ..., C_n$ is the criterion.

$\tilde{x}_{11}, \tilde{x}_{12}, ..., \tilde{x}_{nn}$ is the fuzzy weight value.

3. Calculate geometric arithmetic mean for every raw as the following equation

$$ri = \left(\prod_{j=1}^{n} \tilde{x}_{ij} \right)^{1/n}, \ i = 1, 2, .., n$$

4. To find the criteria weights we calculate the power summation then the normalization values.
5. Defuzziness step(Mi) using center of media method [27] as follows:

$$M_i = \frac{lw_i + mw_i + uw_i}{3}$$

6. Rank the weighted values.

3- GOALS/STRATEGIC PLANNING

3-1 WHAT ARE GOALS?

According to Axel van Lamsweerde [9]:

“a goal corresponds to an objective the system should achieve through the cooperation of agents in the software to be and in the environment”.

Nowadays, a lot of organizations have diverse stakeholders who might be even around the globe. Those stakeholders suffer from some issues such as a difference in stakeholders’ preferences and stakeholder's weights. Those stakeholders address the organization goals. Because of the hierarchy organizational structures for many originations the goals are different in each level. So the goals of different levels of abstraction can vary from high-level (strategic), down to low-level which the goals are related to time. In other words, are the goals suitable for all times or affected by the environments? In the sense explained, may be a goal is more important in the present time but in the future it becomes less important [28], where the relations between goals and environments are diverse, such as laws, competition, diverse stakeholders, requirements constraints, and customer needs. Hence these different environments are related directly to the requirements that represent the base for any development. So if we need to achieve the goals correctly we must identify these requirements correctly too [29], [30].

3-2 CHALLENGES AND RISKS

There are many challenges that face the prioritization activity, which need more attention when using the prioritization techniques, such as [2]:

- Mandatory requirements, as the requirements that needed for satisfying the standard criteria to get the ISO certificate, or the requirements must be applied by law.
- Quality of the requirements; the requirements must be clear and specified well, and avoiding the vagueness.
- Limited resources; limited resources are big issue especially, if the requirements are very large.
- Goals vs. requirements relations; it is a difficult activity to directly relate requirement priority to business goal importance.
- The priorities of requirements change over time; the requirements may be change according to many reasons, as stakeholder's preferences, environments change, adding new requirements or deleting some exciting requirements.
- Stakeholder and developer collaboration.
- Some requirements are in conflict.

4- THE PROPOSED RP TECHNIQUE BASED ON GOALS' WEIGHTS

4-1 THE REQUIREMENTS GOALS DEPENDENCY

Suppose that a project's goals are n goals, and the stakeholders are equally relative weight, then the organization project goals are divided into hierarchal levels as shown in Figure 4.

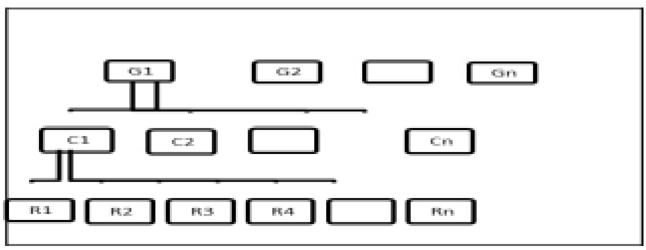

Figure 4 Hierarchal levels project.

Where,
$G_1, G_2, G_3, \ldots, G_n$ are the project goals.
$C_1, C_2, C_3, C_4, \ldots, C_j$ are the criteria needed (attributes) for every goal.
$R_1, R_2, R_3, R_4, \ldots, R_i$ are the requirements for every criteria.
The goal weight is WG according to stakeholders, the criteria weight is WC according to goals and the requirement weight according to criteria is WR and WRG according to goals.

$$\text{WRG} = \frac{\sum_{x=1}^{n} WGx}{n} * \frac{\sum_{y=1}^{j} WCy}{j} * \frac{\sum_{z=1}^{i} WRz}{i} \qquad (1)$$

The enhanced RP technique based on goals' weights
The steps of the technique are as follows:
1- Assume that the stakeholder's weights are equal.
2- The stakeholder's determine the goals weights (G1, G2, G3, ..., Gn) according to our proposed scale from (0-9) as in Table 3, where

$$\sum_{z=1}^{n} G_z \neq 0$$

Table 3 0-9 scale

Scale	Value
0	Not important at all
1	More less important
2	Less important
3	Low important
4	Low moderate important
5	Moderate important
6	High moderate important
7	High important
8	Very high important
9	Strategic important

The idea of this scale can help to reduce the uncertainty issues and convert the AHP, FAHP values scale into the enhanced RP technique based on goals' weights; the idea depends on dividing the scale into four categories as follows:

- From 2 to 4 scale values represent the low importance degrees.
- From 4 to 6 scale values represent the moderate importance degrees.
- From 6 to 8 scale values represent the high importance degrees.
- 9 represent strategic or absolute importance.

3- For every goal the stakeholders assign the criteria weights ($C_1, C_2, C_3, \ldots, C_j$) using scale from 0-9 where:

$$\sum_{z=1}^{n} C_z \neq 0 .$$

4- Design the Goals - criteria matrix according scale from (0:9) as follows:

Suppose X is the cross section between the row and the column so the Goals - criteria matrix design as follows:

$$\begin{array}{c c} & \begin{array}{cccc} G_1 & G_2 & .. & G_n \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ : \\ C_j \end{array} & \begin{pmatrix} x_{11} & x_{12} & .. & x_{1n} \\ x_{21} & x_{22} & .. & x_{2n} \\ : & : & : & : \\ x_{j1} & x_{j2} & .. & x_{jn} \end{pmatrix} \end{array}$$

5- For consolidation the criteria scales should be suitable for the comparison so we design a normalized decision matrix for criteria Cj according to every Goal Gn as the next normalization (1)

$$\text{Normalized matrix } (CG)_{jn} = \frac{C_j G_n}{\sqrt{\sum_{j=1}^{z} (C_j G_n)^2}} \qquad (2)$$

For every $G_1, G_2, \ldots, G_n$

The result of the normalized matrix $(CG)_{jn}$ is the criteria weights according to the goals.

6. Criteria weights = C_j weights * G_n weights for all values in the matrix.
7. For every criteria calculate the arithmetic mean as per (3):

$$C_j(\text{mean weight}) = \frac{\sum_{n=1}^{z} (Cj * G_n)}{z} \qquad (3)$$

For $C_1, C_2, \ldots, C_j$

8. The criteria weights according the goals = CJ (mean weight) Ranked.
9. Design the requirements - criteria matrix according scale from 0-9 as follows:

$$\begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & .. & C_j \end{array} \\ \begin{array}{c} R_1 \\ R_2 \\ : \\ R_I \end{array} & \begin{pmatrix} x_{11} & x_{12} & .. & x_{1j} \\ x_{21} & x_{22} & .. & x_{2j} \\ : & : & : & : \\ x_{i1} & x_{i2} & .. & x_{ij} \end{pmatrix} \end{array}$$

10. Design a normalized decision matrix for requirements R_i according to every criteria C_j as per (4):

$$\text{Normalized matrix } (RC)_{ij} = \frac{R_i C_j}{\sqrt{\sum_{i=1}^{z}(R_i C_j)^2}} \tag{4}$$

For $C_1, C_2, ..., C_j$

The result of the normalized matrix$(R\ C)_{ij}$ is the requirements weights according to the criteria

Requirements weights = R_i weights * C_j weights for all values in the matrix

11. For every requirement calculate the arithmetic mean as per (5)

$$R_i \text{ (mean weight)} = \frac{\sum_{j=1}^{n} R_i * C_j}{n} \tag{5}$$

For $R_1, R_2, \ldots, R_i$

12. The requirements weights according the goals = R_i (mean weight) Ranked.

4-2 ILLUSTRATIVE EXAMPLE

Suppose a project has 3 goals one of these goals is buying an industrial machine with the following data [31], [32]:

Hint: For simplicity calculation we suppose the following relative goals and criteria weights but it is same as requirements weights calculation. This example only to explain how the algorithm is applied but in the future we will introduce a comparative study with respect to other techniques.

1- The relative goals G_1= 0.4, G_2=0.25, G_3=0.35

2- The relative criteria and alternatives decision matrix

	C_1=0.2 Style	C_2=0.35 Reliability	C_3=0.3 Economy	C_4=0.15 Low cost
R_1	7	9	9	8
R_2	8	7	8	7
R_3	9	6	8	9
R_4	6	7	8	6

3- X^2_{ij} matrix

	C_1=0.2 Style	C_2=0.35 Reliability	C_3=0.3 Economy	C_4=0.15 Low cost
R_1	49	81	81	64
R_2	64	49	64	49
R_3	81	36	64	81
R_4	36	49	64	36

4- The normalized matrix according to 3:

	C_1=0.2 Style	C_2=0.35 Reliability	C_3=0.3 Economy	C_4=0.15 Low cost
R_1	0.46	0.61	0.54	0.53
R_2	0.53	0.48	0.48	0.46
R_3	0.59	0.41	0.48	0.59
R_4	0.40	0.48	0.48	0.40

5- The normalized decision matrix according the new relative criteria weight as follows:

$C_1 = G_1 * C_1 = 0.4 * 0.2 = 0.08$
$C_2 = G_1 * C_2 = 0.4 * 0.35 = 0.14$
$C_3 = G_1 * C_3 = 0.4 * 0.3 = 0.12$
$C_4 = G_1 * C^4 = 0.4 * 0.15 = 0.06$

6- The normalized decision matrix weights according C_i is:

	C_1=0.08 Style	C_2=0.14 Reliability	C_3=0.12 Economy	C_4=0.06 Low cost
R_1	0.46	0.61	0.54	0.53
R_2	0.53	0.48	0.48	0.46
R_3	0.59	0.41	0.48	0.59
R_4	0.40	0.48	0.48	0.40

7- The requirements decision matrix weights = $R_i * C_j$

	C_1=0.08 Style	C_2=0.14 Reliability	C_3=0.12 Economy	C_4=0.06 Low cost
R_1	0.0368	0.0854	0.0648	0.0318
R_2	0.0424	0.0672	0.0576	0.0276
R_3	0.0472	0.0574	0.0576	0.0354
R_4	0.032	0.0672	0.0576	0.024

8- The arithmetic mean according to (1) is:

$$R_1 = 0.0547$$
$$R_2 = 0.0487$$
$$R_3 = 0.0494$$
$$R_4 = 0.0452$$

The final ranking related with the goals is R_1 then R_3 then R_2 then R_4

5- EVALUATION FRAMEWORK AND CASE STUDY

In this case study, The decision maker must choose the best supplier (the main goal) from three alternative suppliers according to five criteria. The main frame of the supplier selection for the related company can be represented as shown in Figure 5. We will conduct RP technique based on goal's weights in a comparison of FAHP technique, which is applied by Ayhan [25] in the same case study. Then we will provide the comparison results as the following methodology.

5-1 IDENTIFYING THE EVALUATION CRITERIA

There are many evaluation criteria are used as following [7]:

- Objective measures: the evaluation is designed to measure the following attributes.
  - The required numbers of proccesses
  - The techniques time consumming
  - Ease of use
  - Reliability of results
  - Techniques scaleability
- Evaluation operation
  - Collecting data:
  - Identifying the participants in the evaluation
  - Identifying the goals and its criteria
  - Identifying the requirements or the alternatives according to every criteria
  - The exprtises will deduce the corrosponding criteria or the requirements weighting values. They will provide the new weighted criteria or requirements according to (0-9) scale values.
- Execution the evaluation
  - Identifying the participants, by choosing three experts to perform this evaluation.
  - The experts analyze the proposed case study that are used in the evaluation process, they identify the goals, criteria and the alternatives in the proposed case study, using FAHP technique which is reported by Ayhan [25] as shown in Figuure 5.
  - The data are collected by the experts from the case study, they identify the priority of alternatives and the criteria according to its goal.
  - evrey one of them records the relative weights values for the alternatives and criteria according to scale(0-9)

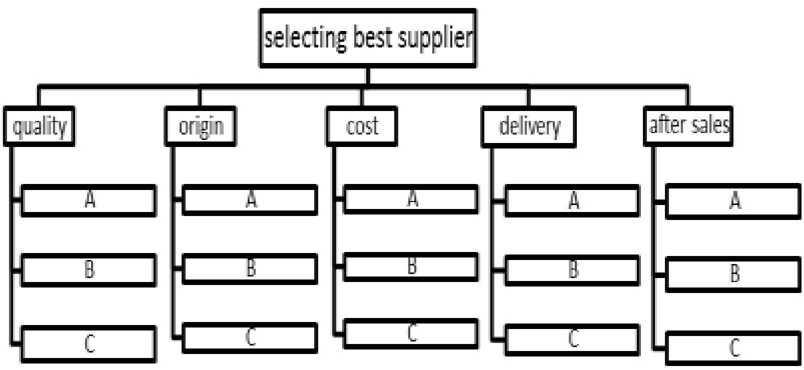

Figure 5 Goal, criteria and alternatives.

- By analyzing the case study by the experts, The following data results , and The analysis for the goals generates the following criteria ranking according to its importane:

  1 The delivery criteria is low important.
  2 The cost criteria is more important than the delivery.
  3 The after sales criteria is more important than cost.
  4 The quality criteria is more important than after sales.
  5 The origin criteria is slightly more important than quality.

Then, they reassigned the goal-based scales values according this analysis as follows:

Criteria	$Expert_1$	$Expert_2$	$Expert_3$
Delivery	2	3	1
Cost	5	4	5
After sales	7	6	7
Quality	8	9	9
Origin	7	9	9

Goal- criteria scale
Quality= 8.33 origin=8.67, cost=4.67, after sales=6.67, delivery=2
So the criteria weights are:

Delivery	Cost	After sales	Quality	Origin
0.07	0.15	0.22	0.29	0.27

1- The relative alternatives weights values according to the criteria and the decision matrix that, are deduced by the experts average results as following.

	Delivery	Cost	After sales	Quality	Origin
A_1	3.000	8.000	8.000	2.000	5.000
A_2	9.000	3.000	3.000	6.000	5.000
A_3	2.000	6.000	7.000	9.000	4.000

2- Matrix square

	Delivery	Cost	After Sales	Quality	Origin
A_1	9.000	64.000	64.000	4.000	25.000
A_2	81.000	9.000	9.000	36.000	25.000
A_3	4.000	36.000	49.000	81.000	16.000
$\sum x^2$	94.000	109.000	122.000	121.000	66.000
$\sqrt{\sum x^2}$	9.695	10.440	11.045	11.000	8.124

4- The normalized matrix according to (3):

	Delivery	Cost	After Sales	Quality	Origin
	0.069	0.138	0.207	0.276	0.310
A_1	0.309	0.766	0.724	0.182	0.615
A_2	0.928	0.287	0.272	0.545	0.615
A_3	0.206	0.575	0.634	0.818	0.492

5- The requirements decision matrix weights = Ri * Cj

	Delivery	Cost	After Sales	Quality	Origin
	0.069	0.138	0.207	0.276	0.310
A_1	0.021	0.106	0.150	0.050	0.191
A_2	0.064	0.040	0.056	0.150	0.191
A_3	0.014	0.079	0.131	0.226	0.153

6- The arithmetic mean according to (5) is:

A_1=0.104
A_2=0.100
A_3=0.121

The ranking is:

A_3
A_1
A_2

The outcomes for RP based-on goal's weights as same as Ayhan's outcomes.

5-2 THREATS TO VALIDITY

There are many threats are Associated with these experiment such as:

1- The author influence: the author wants to provide picture that his assumption or his technique is better than the comparison subject, so the output results are been threated. To reduce the effect of this threat a three of experts are used for the evaluation without author effect.

2- The fixed requirements effect: this threat is produced due to the experts uses the same requirements, when prioritizing the requirements using a specific technique; he will be familiar by the ranked requirements. So, when using the other technique, the previous ranked requirements can take effect in the ranked process. To reduce this threat effect the comparison is made by the experts every two weeks as follow: the three experts performed the case study 1 using FAHP technique, the results are recorded. Two weeks later the experts performed the case study 2 using RP technique, the results are recorded. Two weeks later case study 1 is performed using RP technique and the results are recorded. All the results are collected to be compared and analyzed.

3- The number of experts: this threat due to the low no of expertsexperts may be cause the unreliability measures, to reduce this effect a three of experts are used.

5-3 THE ANALYSIS OF THE COMPARISON BETWEEN GOAL-BASED RP TECHNIQUE AND FAHP TECHNIQUE

We conducted a comparison between our goal-based RP technique and

FAHP on the same case study as part of our evaluation for the new technique. The experts provided the analysis report, for the case study conducted using RP technique, with respect to FAHP technique, the report is summarized in Table 4. Table 4 shows the number of processing criteria and identifies its time consuming needed to perform the case study. To measure the time consuming, we suppose that every process needs 1ms (millisecond). Table 4 provides the measure of the scalability and time consuming, which the requirements and criteria are extended.

Table 4 The measure of the scalability

Criteria	FAHP No of processes	FAHP Time consuming	RP technique based on goal's weights	RP Time consuming
Number of processes for 5 criteria and 2 alternative	180	180 ms	32	32 ms
Number of processes for 5 criteria and 3 alternatives	270	270 ms	58	58 ms
Number of processes for 5 criteria and 4 alternatives	325	325 ms	73	73 ms

Figure 6 shows that, the time consuming is reduced by about (78% to 82%), when using RP technique compared by the FAHP technique time consuming. The comparison results shows that our goal-based technique is more simple and scalable than FAHP, as reported in Table 5. Table 5 shows that the RP technique had enhanced the complexity issue by using a clear and simple algorithme , also, the RP technique provided a very good results in reducing the time consuming, in booth standard and extended requirements or criteria. Finally, the RP technique is very suitable to solve the scalability issue, which the required no of process needed for extened is very small compared with FAHP technique. So, we can claim that the RP technique is a promising technique; however more evaluation will be done in the future work.

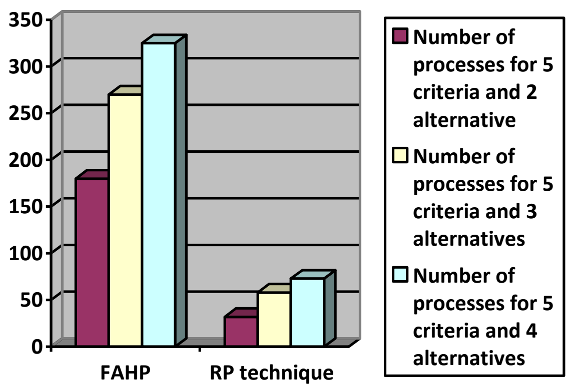

Figure 6 The analysis chart for the comparison results.

Table 5 The comparison results between FAHP and RP techniques

	FAHP	RP technique based on goal's weights
Number of processes for weighting criteria	119	6
Number of processes for 5 criteria and 2 alternative	180	32
Number of processes for 5 criteria and 3 alternatives	270	58
Number of processes for 5 criteria and 4 alternatives	325	73
Ease to use	Complex	Less complex
Time consumpsion	More time consuming	Less time consuming
Scalability	Difficulty in scalability	Scalable

6- CONCLUSION AND FUTURE WORK

In this paper we gave an overview of a number of popular RP techniques available in the literature and their reported drawbacks. This was followed by giving an overview about goals, which is the basis of our new proposed technique. Then we presented our proposed new goal-based technique for RP, which is characterized by giving relative weights to requirements according to a project's goals, with a measuring scale that contains a zero weight to indicate unimportance for reaching more accurate results. We evaluated our technique by the use of case studies that was carried out and presented in the paper. We also conducted a comparison between our technique and FAHP and reported the results. The results turned out in favour of our technique. The analysis of the comparison results showed that the proposed technique is a reliable and promising technique as a prioritization decision making technique.In the future, we intend to continue working on enhancing our new goal-based RP technique to solve problems of uncertainty and data vagueness, in addition to carrying further evaluations of the new technique and carrying comparisons with more than one RP technique from the literature. Finally, study the requirements correlation and the effects of the time dimension of the requirements, the different levels of abstractions, and the criteria will be conducted in the future work.

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