Decision Making Using the Analytic Hierarchy Process (AHP); A Step by Step Approach

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Abstract: - Analytical Hierarchy Process is one of the most inclusive system which is considered to make decisions with multiple criteria because this method gives to formulate the problem as a hierarchical and believe a mixture of quantitative and qualitative criteria as well. This paper summarizes the process of conducting Analytical Hierarchy Process (AHP).

Key-Words: - Analytical Hierarchy Process (AHP), Research Methodology, Hierarchical Tree, AHP Survey / Questionnaire, and AHP Formulas.

1 Analytical Hierarchy Process

Saaty (1980) developed a strong and helpful tool for managing qualitative and quantitative multi-criteria elements involving in decision-making behavior. This model is called Analytical Hierarchy Process (AHP) and is based on a hierarchical structure.

This procedure occupied an assortment of options in the decision and capable to apply sensitivity analysis on the subsequent criteria and benchmarks. In addition, it makes judgments and calculations easy because of paired comparisons. Moreover, it demonstrates the compatibility and incompatibility decisions which is the recompense of multi criteria decision making (Lee, 2007).

Analytical Hierarchy Process is one of the most inclusive system is considered to make decisions with multiple criteria because this method gives to formulate the problem as a hierarchical and believe a mixture of quantitative and qualitative criteria as well. The first step is to create a hierarchy of the problem. The second step is to give a nominal value to each level of the hierarchy and create a matrix of pairwise comparison judgment.

2 Steps to Conduct AHP

At the first stage, the issue and goal of decision making brought hierarchically into the scene of the related decision elements. Decision making elements are decision indicators and decision choices. The group established a hierarchy according to Figure 1 which should reflect the understudy problem.

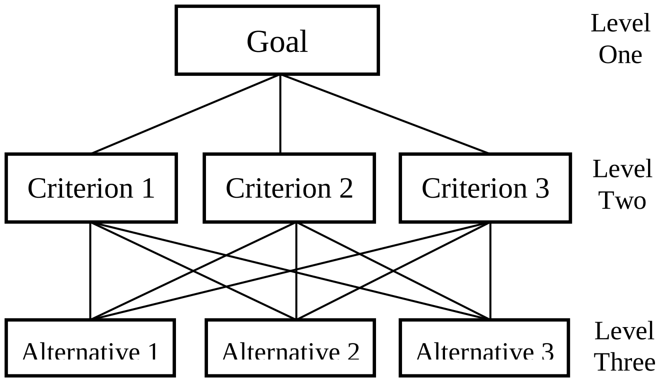

Fig 1: Sample Hierarchical Tree

In second step and in order to conduct pair comparison, a questionnaire should be designed and distributed among the respondents (can be managers, experts, users and etc.) to collect their opinion. It is noteworthy that each decision maker entered their desired amount for each member and then individual judgments (of each respondents) have been converted into group judgments (for each one of the pair comparison) using their geometrical average. The scale ranges from one to nine where one implies that the two elements are the same or are equally important. On the other hand, number nine implies that one element is extremely more important than the other one in a pairwise matrix. The pairwise scale and the importance value attributed to each number are illustrated in the Table 1. Table 2 shows the sample of the questionnaire.

Table 1: Scores for the importance of variable

Importance Scale	Definition of Importance Scale
1	Equally Important Preferred
2	Equally to Moderately Important Preferred
3	Moderately Important Preferred
4	Moderately to Strongly Important Preferred
5	Strongly Important Preferred
6	Strongly to Very Strongly Important Preferred
7	Very Strongly Important Preferred
8	Very Strongly to Extremely Important Preferred
9	Extremely Important Preferred

Table 2: Sample AHP Questionnaire

How important are the following security criteria in comparison

Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Factor
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reliability
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Validation
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Verification
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Integrity
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Confidentiality
Privacy	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Availability

The data analyze procedure involves the following steps. First the pairwise comparison matrix which is called matrix A is extracted from the data collected from the interviews. The principal right eigenvector of the matrix A is computed as ‘w’.

If $a_{ik} \cdot a_{kj} = a_{ij}$ is not confirmed for all *k, j, and i* the Eigenvector method is selected (Jalaliyoon, et al., 2012).

If the matrix is incompatible and in case of incomplete consistency, pair comparisons matrix cannot be used normalizing column to get Wi.

For a positive and reversed matrix, Eigenvector technique can be used which in it:

$$e^T = (1,1,\ldots,1)$$

$$W = \lim_{k\to\infty} \frac{A^k . e}{e^T . A^k . e}$$

To reach a convergence among the set of answers in to successive repetition of this process, calculation should be repeated several times in order to take a decision when facing an incompatible matrix. Then, the following formula is applied to transform the raw data into meaningful absolute values and normalized weight w = (w_1, w_2, w_3… w_n):

$$Aw = \lambda_{max}\, w, \quad \lambda_{max} \geq n$$

$$\lambda_{max} = \frac{\sum a\, jwj - n}{w1}$$

A={a_{ij}} with a_{ij}=1/ a_{ij}

A: pair wise comparison
w: normalized weight vector
λ_{max} : maximum eigen value of matrix A
a_{ij}: numerical comparison between the values i and j

In the next step, in order to validate the results of the AHP, the consistency ratio (CR) is calculated using the formula, CR = CI/RI in which the consistency index (CI) is, in turn, measured through the following formula:

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

The value of RI is related to the dimension of the matrix and will be extracted from Table 3. It should be noted that consistency ratio lower than 0.10 verifies that the results of comparison are acceptable.

Table 3: The value of Random Consistency Index, Source: Golden and Wang (1990)

Dimension	*RI*
1	0
2	0
3	0.5799
4	0.8921
5	1.1159
6	1.2358
7	1.3322
8	1.3952
9	1.4537
10	1.4882

A
k

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