

Analytical Hierarchy Process

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Abstract— Analytical hierarchy process is an important software quality model. AHP is “a method of breaking down a complex, shapeless situation into its workings parts; arranging these parts, or judgment on the relative importance of each variable; and synthesizing the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation”. This article give a general idea of analytical hierarchy process which combines two approaches- the “black and white” of mathematics, and the subjectivity and intuitiveness of psychology- to evaluate information and make decisions that are easy to defend.

Key words: Analytical Hierarchy Process, Decision Making, Functions, Application, Uses

I. INTRODUCTION

Analytical Hierarchy Process is a decision making technique developed by mathematician Thomas L. Saaty. AHP can be used in making decisions that are complex, amorphous, and contain multiple attributes. AHP provides a method to connect that can be quantified and the subjective judgment of the decision maker in a way that can be calculated. In applying AHP to benchmarking, Partovi describe the procedure in three wide steps: the description of a complex decision problem as a hierarchy, the prioritization process, and the calculation of consequences.

II. HISTORY

In the late 1960's, Thomas Saaty, one of the pioneers of Operations Research, and author of the first Mathematical Methods of Operations Research textbook and the first queue textbook, was direct research projects for the Arms Control and Disarmament Agency at the U.S. Department of State. Saaty's very generous budget allowed him to recruit some of the world's leading economists and game and utility theorists. In spite of the talents of the people Saaty recruited (three members of the team, Gerard Debreu, John Harsanyi, and Reinhard Selten, have since won the Nobel Prize), Saaty was disappointed in the results of the team's efforts.

Years later, while teaching at the Wharton School, Saaty was troubled by the communication difficulties he had observed between the scientists and lawyers and by the apparent lack of a practical systematic approach for priority setting and decision making. Having seen the difficulty experienced by that the world's best scientists and lawyers, Saaty was motivated to attempt to develop a simple way to help ordinary people make difficult decision. The result was the Analytic Hierarchy Process – a synthesis of existing concepts that attests to Saaty's intelligence through its power and simplicity.

III. ANALYTIC HIERARCHY PROCESS (AHP): A MULTIPLE CRITERIA DECISION-MAKING TOOL

Analytic Hierarchy Process is a numerous criteria supervisory tool. This is an Eigen value approach to the pair-wise comparisons. It also provides a method to standardize the numeric scale for the measurement of quantitative as well as qualitative performances. The scale ranges from 1/9 for \hat{O} least valued than \tilde{O} , to 1 for \hat{O} equal \tilde{O} , and to 9 for \hat{O} absolutely more important than \tilde{O} , covering the entire spectrum of the comparison. A few key and basic steps involved in this method are:

- 1) State the problem.
- 2) Broaden the objectives of the problem or consider all actor, objectives and its conclusion.
- 3) Identify the criteria that impertinence the behavior.
- 4) Structure the problem in a hierarchy of deferent levels constitutes goal, criteria, sub criteria and alternative.
- 5) Compare each element in the corresponding level and calibrate them on the numerical scale. This requires $n(n-1)/2$ comparisons, where n is the number of elements with the considerations that diagonal elements are equal or $\hat{O} = \tilde{O}$ and the other elements will simply be the reciprocals of the earlier comparisons.
- 6) Perform calculations to find the maximum Eigen value, constancy index CI, reliability ratio CR, and normalized values for each criteria/alternative.
- 7) If the maximum Eigen value, CI, and CR are reasonable then decision is taken based on the normalized values; else the procedure is repeated till these values lie in a desired range.

AHP helps to integrate a group agreement.

Generally this consists of a survey for comparison of each element and geometric mean to arrive at a final solution. The hierarchy method used in AHP has various advantages.

IV. STEPS INVOLVED

The steps involved in this process are:

A. Build Your “Hierarchy”

- 1) Define your goal or objective.
- 2) Identify the choices you're considering.
- 3) Outline the major factors needed to evaluate each option.
- 4) Identify criteria.
- 5) Continue to build a hierarchy of decision criteria until all factors are identified and linked.

B. Establish Your Priorities

- 1) Using comparison, determine criteria preferences.
- 2) Rate these preferences.
- 3) Repeat this for each level in hierarchy.

C. Synthesize Or Combine The Ratings.

Calculate weighted criteria scores that combine all of the ranking data.

D. Compare the Alternatives:

- 1) Using those combined scores, calculate the final score for each alternative.
- 2) The Analytic Hierarchy Process can help to quantify the judgments used in decision making. When problems become complex, it's hard to justify and explain all the reasons why one alternative is better, or more preferable, than another. With AHP, weighted scores for each set of criteria are calculated and then those weights are used to calculate the final score for each alternative. Whether this approach is used to make a final choice or as one of many tools in decision making process, the result is remarkably clear.
- 3) To rate the attributes of quality model the scale used is from 1-6 (or the no. of attributes or their sub attributes) where 1 being the least preferred and 6 – the highly preferred or most important.
- 4) There are certain disadvantages to using the analytic process to measure your quality. Firstly, the subjective scale (“much more important”) is very useful in software quality analysis but precisely because the scale is subjective; it is subject to human error. Another disadvantage of the analytic hierarchy's subjective scale is that it is vulnerable to human psychology as the rankings can be inflated in order to see the improvement in quality. The biggest disadvantage of using the analytic hierarchy process is that the number of comparison tables can become very large if a lot of comparison attributes are used. This can lead to a tendency to exclude valid comparison attributes in order to keep the number of calculations manageable.

V. WHY AHP IS SO WIDELY APPLICABLE

Any complex situation that require structuring, dimension, and and/or synthesis is a good candidate for AHP. However, AHP is rarely used in partition. Rather, it is used beside with, or in maintain of other methods. For example to produce the results of other methods such as in deciding how many servers to employ in a queuing situation taking into account waiting times, costs, and human aggravation, or to derive probability for a decision tree. Wide areas where AHP has been effectively employed include: selection of one substitute from many; resource allocation; forecasting; total quality management; business process re-engineering; quality principle deployment, and the reasonable scorecard.

VI. USES AND APPLICATION

Decision situation to which the AHP can be applied include.

Choice – The choice of one alternative from a given set of alternative, usually where there are multiple decision criteria involved.

- 1) Ranking – put a set of alternatives in order from most to least desirable.

- 2) Prioritization – formative the relative merit of members of a set of alternatives, as opposed to selecting a single one or merely ranking them
- 3) Resource Allocation– apportion resources among a set of alternatives
- 4) Benchmarking– compare the processes in one's own organization with those of other best-of-breed organizations
- 5) Quality Management– Dealing with the multidimensional aspects of quality and quality improvement
- 6) Conflict Resolution– settle disputes between parties with it appears that mismatched goals or positions

VII. THREE PRIMARY AHP FUNCTIONS

AHP has been applied in a wide variety of applications – versatile decision making being just one. A look at the three primary functions of AHP, structuring complexity, measurement, and combination helps in understanding why AHP is such a general methodology with such a wide variety of applications.

A. Structuring Complexity:

Saaty sought a simple way to deal with complexity. Simple sufficient so that lay people with no formal training could understand and contribute. He found one thing common in numerous examples of the ways humans had dealt with complexity over the ages – that was the hierarchical structuring of complexity into identical cluster of factor.

B. Measurement on a Ratio Scale:

Whereas earlier decision making methods relied on lower levels of measurement (Electric using ordinal measurement and MAUT interval measurement) Saaty's mathematical training convinced him that ratio scales would most accurately measure the factors that comprised the hierarchy. This also was not a new idea.

According to Stevens' [1946] measurement classification scheme, there are four levels of measurement. The levels, ranging from lowest to highest are supposed, Ordinal, period, and Ratio. Each level has all of the meaning of the levels below plus additional meaning.

For example, a ratio measure has ratio, interval, ordinal and supposed meaning. An interval measure does not have ratio meaning, but does have interval, ordinal and supposed meaning. Ratio measure is necessary to represent proportion. Whereas the Proportions in Monet's paintings, for example, are representative of the world as most people see it, Picasso's paintings are treasured for their thought frustrating qualities, but are not good models of the real world. In keeping with his search for as simple a methodology as possible, Saaty proposed using judgments of the ratios of each pair of factors in the hierarchy to derive (rather than assign) ratio scale measures.

C. Synthesis:

Analytic, the first word in AHP's name is a form of the word analysis, which means separating a material or abstract entity into its constituent elements. Analysis is the opposite of synthesis, which involves putting together or combining parts into a whole. Because complex, vital decision situations, or forecasts, or resource allocations often involve

too many dimensions for humans to synthesize spontaneously, we need a way to synthesize over many dimensions.

High level corporate decisions meetings may have associate president of finance, marketing, operations, information systems, and human resources sitting around a conference table, each 'armed' with the results of analyses that their departments have performed. Each may also have reached a different conclusion as to what is best for the organization. The impasse usually is not because of a lack of good Analyses , but a lack of ability to manufacture the analyses that have been made.

VIII. HOW AHP WORKS

AHP is used to first decay the decision problems into a hierarchy of easily comprehend sub-problems, each of which can be analyze independently. The elements of the hierarchy can narrate to any aspect of the decision problem tangible or intangible, estimated or carefully measured, well or poorly understood. Once that hierarchy is recognized, the decision maker systematically examines the various elements, comparing them to each other in pairs. In making the comparisons, the decision maker can use his/her judgments about the elements' relative meaning and importance, or they can use well refined data about the elements. AHP converts the judgments to numerical values that are processed, evaluated and compared over the entire range of the decision problem. A numerical weight or priority vector is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes AHP from other decision making techniques. At the end of the process, numerical priorities are derived for each of the decision alternatives. It is then a simple matter to pick the best alternative, or to rank them in order of relative preference.

IX. IMPORTANCE OF AHP

AHP is very useful when the decision-making process is complex, for instance, by being amorphous, it has been applied to numerous various fields (government, business, industry, healthcare, and education) and has proven to be a powerful decision-making tool. In management, it has been fruitfully employed in resource allocation, forecasting, total quality administration, business process re-engineering, quality function deployment and the balanced scoreboard.

In higher education, AHP has been useful in areas to include economic support research support requests, deciding on time off proposals, assessing performance and allocating rewards or reimbursement, choosing students for admission, financial aid, learning and award, and faculty selection. AHP is best used along with or in support of other decision making methods, example, when using a decision tree to analyze substitute choice nodes of a decision tree, as well as to derive priority for alternatives at the extremity of the decision tree.

More so, because AHP helps capture both subjective and objective evaluation measures, providing a useful mechanism for examining the consistency of the assessment measures and alternatives suggested by the decision maker thus it reduces biasness in the decision

making process. AHP allows organizations to decrease widespread pitfalls in decision making process, such as lack of focus, planning, association or ownership, which eventually are costly distraction that can prevent the decision maker from making the right choice.

X. CONCLUSION

We have examined the history and development of AHP. The three primary AHP functions of structuring complexity, measurement and synthesis make AHP applicable to a wide range of applications, not just choice problems. AHP's axiom are few, simple, and with the exception of the hierarchic masterpiece axiom (that specifies that power flows down but not up), in consonance with all real world situations we have encountered. For those situations where higher levels of a hierarchy are influenced by lower levels, we have described three ways to apply or modify the AHP process -- iteration, bottom up assessment, and feedback with super environment calculations.

Although numerous organizations in both the private and public sectors have already benefited from the use of AHP, there is far more an organization still unaware of a process such as AHP that is theoretically sound, understandable, and matches their expectations. We hope that this exposition will help in making these organizations aware of a viable alternative to applying inferior common simplistic strategies to important decisions.

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