Analytic Network Process (ANP)

What is ANP?

The **analytic network process** (**ANP**) is a more general form of the analytic hierarchy process (AHP) used in multi-criteria decision analysis (MCDM).

AHP vs ANP

AHP structures a decision problem into a hierarchy with a goal, decision criteria, and alternatives, while the ANP structures it as a network. Both then use a system of pairwise comparisons to measure the weights of the components of the structure, and finally to rank the alternatives in the decision.

Multi-Criteria Decision Making (MCDM)

Multiple-criteria decision-making (**MCDM**) or **multiple-criteria decision analysis** (**MCDA**) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making. MCDM is used to find the influential nodes by considering many criteria which are nothing but the centrality measures in a network.

How is ANP better among other MCDM methods?

Recently, MCDM methods have been widely considered by researchers and scientists. These methods have great application in various fields of science, including management, engineering, science and business, to help decision makers make good choices. Evaluating, selecting, ranking and sorting alternatives are the purposes of using such methods.

The review of the MCDM literature reveals that there has been no extensive study on the application of ANP in different fields so far. ANP is the generalized from of AHP. In addition to the hierarchical structure, the relationship among criteria is also considered in ANP. Indeed, ANP provides a network of relationships among criteria, which leads to more reliable results.

ANP in Decision Making

The Analytic Network Process (ANP) for decision-making with dependence and feedback is a comprehensive framework for the analysis of societal, governmental and corporate decisions. It is a process that allows one to include all the factors and criteria, tangible and intangible, which have a bearing on making a decision. The ANP allows both interaction and feedback within clusters of elements (inner dependence) and between clusters (outer dependence). Such feedback can capture the complex effects of interplay in human society, and this is especially important when risk and uncertainty are involved.

In MCDM, under each control criterion there is a network of influences among the elements and clusters of the decision problem, which must include a cluster of the alternatives of that decision. These influences are determined through paired comparisons that lead to priority vectors included as the columns of a matrix of interactions among the elements of two clusters (or the same cluster) in which the interactions take place.

The interactions matrices comprise the entries of a supermatrix that is raised to powers to capture the transitivity of influence among all the elements and determine the overall priorities of all the elements in the network particularly those of the alternatives. For the supermatrix to converge one needs to determine, each time using a paired comparisons matrix of judgments, the influence of the clusters on a given cluster with respect to the control criterion. The vector of priorities derived from the comparisons is then used to weight the corresponding column of matrix entries of the supermatrix corresponding to the influenced cluster. One number multiplies an entire matrix entry of the supermatrix. The number is the corresponding component of the vector of cluster priorities. Each column of the resulting supermatrix now sums to one. It is known as a column stochastic matrix.

The priorities of the alternatives thus derived are then put in ideal form by dividing each value by the largest value among them, and then weighted by the priority of their control criterion. The weighted priorities of the alternatives under the several control criteria under benefits are then summed to obtain the overall outcome with respect to benefits. The

outcomes are each rated with respect to the strategic criteria and the ratings normalized and used to weight the four vectors and sum the results for the benefits and opportunities and then also for the costs and risks and subtract the second sum from the first to obtain the final overall outcome. The resulting priorities for some or for all the alternatives can have negative values.

Sometimes, when all the values are negative one chooses the alternative with smallest negative value for the decision as the best of the worst possible choices, which can happen often, for example, in case of badly injured soldiers in a war. The ANP has been applied to a large variety of decisions: marketing, medical, political, social, forecasting and prediction and many others. Its accuracy is impressive in predicting economic trends, winners in sports and other events for which the outcome later became known.

ANP Pseudocode

```
// INPUT: Graph G = (V, E), influence spread function f, integer k

// OUTPUT: k influential nodes

1. Initialize the set of selected influential nodes S = ∅
2. while |S| < k do:
3.     Find a node v not in S that maximizes f(S ∪ {v})
4.     Add v to S
5. end while
6. return S
```

Improvisation Did

The main difference between Analytic Hierarchical Process (AHP) and Analytic Network Process (ANP) is, in AHP the comparison matrix is used to only compare the results of the centrality measures, here the centrality measures that are used to calculate the score are degree centrality, betweenness centrality and eigenvector centrality. Whereas in ANP, the comparison matrix is used to compare and also used in processing the results to calculate the score. Thus producing better results compared to AHP.