Home Decoration Service Provider Selection Using Analytic Network Process (ANP)

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Abstract

Nowadays, everybody is facing many problems with making decisions and future planning of global and regional works all over the world. The analytic network process (ANP) is one of the most widely used multiple criteria decision making (MCDM) methods. The ANP is highly recommended because ANP allows interdependent influences specified in the model. In many real world cases, there is interdependence and feedback among the elements and alternatives. The ANP is a useful tool for prediction and representing a variety of competitors with their surmised interactions and their relative strengths to wield influence in making a decision. Feedback and dependence improve the priorities derived from judgments and make prediction more accurate. The Analytic Network Process (ANP) technique has been developed for service provider selection in home decoration. Without a proper and accurate method for selecting the most appropriate contractor, the performance of the project will be affected. The ANP can lead to real life answers that are matched by actual measurements in the real world.

Keyword: Analytic Network Process, ANP, MCDM, Decision Making, Decision support system

1. Introduction

Decision Support Systems (DSSs) are a specific class of computerized information system that supports business and organizational decision making activities. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and business models to identify and solve problems and make decisions. Decision is the choice of one from among a number of alternatives, a statement indicating a commitment to a specific course of action [2]. Decision Support System (DSS) is interactive information that provides information, models and data manipulation tools to help make decisions in semi-structured and/or unstructured situation where no one knows exactly how the decision should be made. The internet plays an important role in this service industry. So, this system functions as a web-based decision support system with analytic network process model to select best service provider for home decoration package. This selection is one of the main decisions made by the clients. In order to ensure that the project can be completed successfully, the client must select the most appropriate service provider. Many methodologies may not support the influence of each criterion on its selection. The Analytic Network Process (ANP) can provide dependence and feedback. It allows for more complex interrelationships among decision elements [1]. The ANP is a Multi-Criteria Decision Making (MCDM) methodology aimed at setting priorities of alternatives or selecting the best alternatives. Feedback improves the priorities derived judgment and makes prediction more accurate.

2. Motivation

Nowadays, the web technology is the center of activity in developing Decision Support System (DSS) and can be expected to result in organizational environments that will be increasingly more global, complex, and connected. The advent of the web has enabled inter-organizational decision support systems, and has given rise to numerous new applications to existing technology as well as many decision support technologies themselves. Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements in a hierarchy on lower level elements. The ANP is a useful tool for prediction and for representing a variety of competitors with their surmised interactions and their relative strengths to wield influence in making a decision. Feedback improves the priorities derived from judgments and makes prediction more accurate. In real life problems involve dependence and feedback, so ANP is effective tool for proposed system. Decision with the ANP should be more stable because one can consider their effect on and survival in the face of other influences [6]. By using ANP model, we can get accurate answer as we consider the dependencies and interrelationship among criterion and elements. Systematic thinking is essential in decision making to represent decision in the framework of a network. The ANP is a way to implement this type of thinking.

3. Related Work

Analytic Network Process (ANP) is a generic form of Analytic Hierarchy Process (AHP) and allows for more complex interdependent relationships among elements. It is also known as the systems-with-feedback approach. Contractor selection is one of the main decisions made by the clients. In order to ensure that the project can be completed successfully, the client must select the most appropriate contractor. The proposed approach could be used to address a variety of different problems, such as the forecast of competitive companies' market shares, the right choice of an investment etc [7]. Design alternative evaluation of bridges is an important decision making process before a new types of bridge may be built. The decision process is often to select the best of bridge designs under the same span length, load carrying capacity, carriageway width and vertical clearance. In view of the worldwide trend, it become more significant to develop a strategy and a systematic evaluation method of the overall performance of bridge design alternatives, because of method used directly affects decision result [5]. The forecasting a new product is a complex and risky endeavor mainly due to the minimal data, limited analysis time and a general uncertainty surrounding a new product and the marketplace. Further, judgmental forecasting techniques and experts opinions are proved to be the most accurate approaches. The ANP approach incorporates both qualitative and quantitative factors and exploits expert's tacit knowledge in order to provide accurate predictions for new product sale.

4. Background Theory

4.1 Analytic Network Process Model

It allows the simultaneous inclusion of tangible and intangible criteria, incorporates feedback and interdependent relationships among decision criteria and alternatives. Technically, the model consists of clusters and elements. The dominance or relative fundamental scale (presented in Table 1) by answering the question: which of the two elements Y, Z influences a third element X more with respect to the control criterion? In order that all such influences be considered with respect to the same criterion so they would be meaningful to synthesize, it is essential that the same criterion be used to make all the comparisons. Such a criterion is called control criterion. A control criterion is an important way to focus thinking to answer the question of dominance, thus first decomposing a complex problem with a variety of influences and then pulling it back together by using the weights of these influences. The control criterion is directly connected to the structure of the problem and it usually represents the goal [4].

Table 1.The fundamental scale used in ANP

Intensity of importance	Importance
1	Equal important
3	Moderate importance of one over another
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate values

Use reciprocal for inverse compare. In short, the ANP approach handles interdependence among elements by obtaining the composite weights through the development of a "supermatrix", by following six steps:

- Step 1 – Model Construction.
- Step 2 – Clusters' pair-wise comparisons and Cluster priority matrix.
- Step 3 – Elements pair-wise comparisons.
- Step 4 – Formation of Un-weighted super-matrix.
- Step 5 – Formation of Weighted super-matrix.
- Step 6 – Formation of Limiting super-matrix.

Step 1 – Model Construction: The development of the forecast model is a core procedure that plays an important role in the model's outcome. The most critical matter is to define the criteria that have to be included in the model. The structure of the model is described by its clusters and elements and the connections among them. These connections indicate the flow of influence among the elements. The definition of the connections among elements can only be defined by a decision maker, who is an expert in terms of knowing how the elements interact in the real environment. Moreover, the definition of the connections can be even more subjective and include decision maker's preference/beliefs on how the model should be constructed.

Step 2 – Clusters' pairwise comparisons and clusters priority matrix : After the model has been constructed, the elements in a cluster were

compared by applying Saaty's 1-9 scales according to their influence on an element in another or even the same cluster to which they are connected. The values of local priorities can be derived from equation (1) and (2).

$$a_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \quad j = 1,2,\ldots,n \qquad (1)$$

$$w_{ij} = \frac{\sum_{j=1}^{n} a_{ij}}{n} \quad j = 1,2,\ldots,n \qquad (2)$$

Where a_{ij}, is the relative weight of the i^{th} components over the j^{th} components. W_{ij} is the local priority vector.

Step 3 – Elements' pairwise comparison: In order to compare the elements of the clusters, the same procedure, as the one described in the former step was followed.

Step 4 – Formation of the Un-weighted super matrix: The priorities of the elements are arranged both vertically and horizontally according to clusters. This matrix is known as the supermatrix. Each vector taken from a paired comparison matrix is part of the column of the supermatrix representing the impact, with respect to the control criterion of the elements of that cluster on a single element of the same or another cluster.

The Supermatrix of a Network

$$W = \begin{array}{c} \\ C_1 \\ \vdots \\ C_2 \\ \vdots \\ C_N \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_N \\ e_{11}\, e_{12} \ldots e_{1n1} & e_{21}\, e_{22} \ldots e_{2n2} & \cdots & e_{N1}\, e_{N2} \ldots e_{NnN} \end{array} \\ \begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1N} \\ W_{21} & W_{22} & \cdots & W_{2N} \\ \vdots & \vdots & \cdots & \vdots \\ W_{N1} & W_{N2} & \cdots & W_{NN} \end{bmatrix} \end{array}$$

W_{ij} Component of Supermatrix

$$W_{ij} = \begin{bmatrix} W_{i1}^{(j_1)} & W_{i1}^{(j_2)} & \cdots & W_{i1}^{(j_{nj})} \\ W_{i2}^{(j_1)} & W_{i2}^{(j_2)} & \cdots & W_{i2}^{(j_{nj})} \\ \vdots & \vdots & & \vdots \\ W_{ini}^{(j_1)} & W_{ini}^{(j_2)} & \cdots & W_{ini}^{(j_{nj})} \end{bmatrix}$$

Figure 1: The super-matrix of the Network

Where C_k is the k^{th} cluster (k=1, 2, N).W_{ij} represents a relationship between the i^{th} cluster and the jth cluster. Each column of W_{ij} is a local priority vector obtained from the corresponding pair-wise comparison.

Step 5 – Formation of the weighted super-matrix: The weighed priorities at the Clusters Priorities Matrix are used to weight all the elements in the block of column priorities of the supermatrix, according to the impact of the elements of that cluster on another cluster. This process is repeated for all the clusters resulting in the Weighted Super-matrix.

$$\text{Weighted supermatrix} = \text{Cluster priority matrix from Step 2} * \text{Unweighted Supermatrix from Step 4} \qquad (3)$$

This equation (3) is active for only dependent column of the two matrixes to get weighted super matrix.

Step 6 – Formation of the Limit supermatrix : The Limit Matrix and the system's solution derives from multiplying the Weighed Super matrix (Step 5) by itself, until the system's row values converge to the same value for each column of the matrix by using equation (4).

$$W_{global} = \lim_{k \to \infty} W^k \qquad (4)$$

The values of this limit matrix are the desired priorities of the elements of the decision network with respect to the goal.

5. Overview of the System

The system considers selection the best service provider when the user needs to make decision for their home decoration. The user can browse decoration items and packages, and then can make decision for most appropriate contractor. This system has two main parts, user and administrator. This system browses decoration information and home decoration packages for user and the following steps:

(1) User can choose type of category and enter estimate budget.

(2) The system display decoration packages, less than user's budget based on category.

(3) User can choose favorite package design and replace favorite items.

(4) The system displays service provider list according to user selected package design.

(5) Process with ANP and display the best service provider for decorating.

In the administrator part, the admin can edit new information and update or delete existing information.

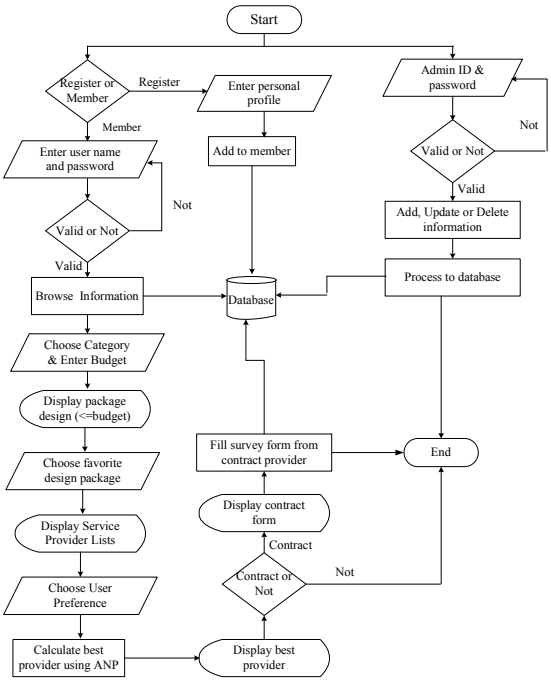

Figure 2.Data Flow Diagram for the system

5.1 Steps of the System Using Analytic Network Process Model

Step 1 Setting up Network

In the first step, the problem must be structured in a network. The proposed system uses the intangible criteria to select the best control for home decoration based on providers' ability. This system model is illustrated in figure-3 consists of five clusters and twelve elements.

(1) The past performance cluster consists of failure to contract, finish in time and quality assurance.
(2) The past experience cluster consists of scale of projects completed, experience in local area.
(3) The characteristic of provider cluster comprises tender price, warranty and reputation.
(4) The operations consist of installation speed in the field.
(5) The alternatives cluster comprises of three possible providers.

For example, the arrow from the cluster past performance to the cluster past experience and the cluster operation means that some of the elements of the clusters past experience and operation influence some of the elements of the cluster past performance. In this case, finish in time under past performance is influenced by installation speed under operation cluster and experience in local area under past experience cluster. Then reputation under characteristic cluster is influenced by quality assurance under past performance, scale of projects completed and experience in local area under past experience, tender price under characteristic cluster.

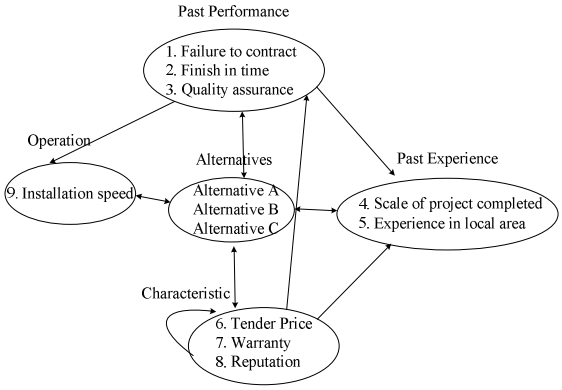

Figure 3.A Network Model for the system

Step 2 Clusters' pairwise comparison and cluster priority matrix

In ANP, once the elements and clusters are formulated the interrelationships among them are represented by "Network" of influence. The intensity of preference is assigned using relative weights (fundamental 1-9 scale) between each pair to elements or clusters with respect to the controlling element.

For example, Does the Past Performance of the provider or the Characteristics influence more the selection of providers and how much more? The value of 3 means that with respect to the cluster Alternatives, the opinion is that Past Performance are moderately more important than Characteristics, meaning that Characteristics is slightly favored over the Past Performance. To obtain the value of local priorities this system used equation (1) and (2).

Step 3 Elements' pair-wise comparison

The elements of the cluster are pair-wise compared and calculated the local priorities by using the same procedure above.

Step 4 Formation of Un-weighted super-matrix

The Un-weighted super-matrix is constructed from the priorities derived from the different pair-wise comparisons. The priorities of the elements are arranged both vertically and horizontally according to clusters. If there are twelve elements in system model, twelve by twelve matrix will be generated. This matrix is known as the Un-weighted super-matrix.

Step 5 Formation of Weighted Supermatrix

The weighted super-matrix is obtained by multiplying each entry in a block of Un-weighted super-matrix by the priority of influence of the component on the left from the cluster matrix by using equation (3). This multiplication is only take place interdependence cluster columns in matrix.

Step 6 Formation of Limiting Supermatrix

The Limiting super-matrix is obtained by multiplying the weighted super-matrix by itself until the system's row values converge to the same value for each column of the matrix by using equation(4). The final priority for the provider is extracted from the Limit matrix.

6. Conclusion

This web-based decision support system not only supports the user to contract with the appropriate service provider for decorating, it also functions as an electronic commerce portal for vendors to trade and advertise the decorating products and expertise. One of the greatest values of the ANP framework is its ability to capture one's thinking about selecting best service provider, especially when data does not exist or there are many intangible criteria. The ANP is now widely used in decision making with dependence and feedback. By using ANP model, accurate answer can be get and interrelationships among criterion and elements can be considered. Analytic Network Process bears a few limitations. First, the ANP uses the pair-wise comparison matrix. It is a computationally intensive task, requiring a significant amount of time by the analyst. In this system, there are nine criteria for making decision. For further extension, there are many factors for selecting contractors such as financial capability, current workload, resources, etc [3]. The outcome of the model depends on the factors provided by the decision makers. The factor is considered to be necessary for the decision making processes as it engages the physiological aspects of the human nature, it can be restricted in some cases. These limitations are not considered to be restrictive for the best service provider selection problems.

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