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Selection of Best Laptop for Educational Purpose by Using ANP

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In every aspect of human life such as social, economic, educational, political and cultural decision making and choosing the right decision is one of the most important actions. In this modern world humans are now fully depending on the Laptop for their educational purposes like reading books, browsing internet, writing class notes, preparing reports, learning various programming languages and coding's, learning various engineering design software's and so on. But when a man or a woman wants to buy a Laptop for his educational purposes, he or she falls in a confusing situation because a variety of alternatives are in the market. This paper provides information through identifying and ranking best alternative (Laptop) reliant on numerous decision making criterion that are attained through studying and processing two hundred samples. In this study, ANP tool (an MCDM technique) is utilized to find out the best Laptop for educational purpose.

Field of Research: Management

1. Introduction

Now it is the era of technology. Today in our every aspect of life we depend on science and its creations. Similarly, today we depend on computer for our regular study. A student can't think a single day without a laptop for his educational purpose because of its advantages. Today students collect their books or other educational informative materials from Google or Wikipedia and download them in their Laptop. As a result a student today rest on the laptop for his institutional study as well as the others study that enrich his general knowledge. Today in the era of science everyone should know about the usages of various software's and programs that make his life easier. So, everyone must buy a laptop for his educational purpose because he can read his necessary books from the Laptop and also learn about the software's that need for his student life and job life. Today students are like these types of laptop having updated features as well as think about their payment affordability. But when a buyer goes to the market for buying a laptop or desktop, he can't decide which laptop he should buy. Most of them can't decide which one is suitable for him or her because a variety of information's are given by the sellers to the customers and then the buyers compare and decide to select the best alternative (Srichetta and Thurachon, 2012). In such situation a prudent buyer will buy a Laptop that follows his requirements. But, in practical situation, the buyers have to face with a variety of Laptops or Desktops information types that are tough to determine the decision alternatives. The objective of this study is to identify and evaluate customers demanded features for selecting a laptop. Furthermore, these customers demanded features are considered as the criterion in this study. This study also provide a

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decision support system that ensures the availability of the viable and structured information about the criteria and corresponding best laptop alternative that will help to expedite the rate of purchasing the best laptop. The new thing of this investigation is that mostly demanded features are taken as criteria that help a new buyer to select the suitable alternative.

The implementation of decision support system in the case of complicated decision making situation and mitigating the real life decision making problems is one of main motivation behind this investigation. In previous years, AHP has been utilized to resolve various kind of decision making problem. But, present scenario shows that the criteria of a decision making problem are correlated to each other. When an individual want to purchase a laptop for his educational purpose, he can't take the right decision. This is another reason to carry out this investigation. Moreover, a hierarchical and a network structure of laptop selecting problem are also included in this study so that anyone can understand the theme of resolving such kind of decision making problems in their every aspect of life.

By incorporating the ANP technique in this problem a suitable laptop is identified. The main reason of incorporating the ANP instead of AHP is the interdependency problem of the criteria of this problem to each other. This problem can also be solved not considering the relationship of the criteria. But, it is found that none of the criteria is independent and that is why we use ANP in this investigation. As a result of use ANP a better result has been found in this study. Srichetta and Thurachon (2012) had applied Fuzzy Analytic Hierarchy Process to evaluate and select product of notebook computers but if they use ANP then they can get better result. They had been thought that the criteria of that problem were independent. In a recapitulate, it can be confidentially said that our findings are different from the others and it is fully a new evaluation and implementation of ANP in our today's life.

This paper arranged as follows - Section 2 give idea about the previous work to identify the research scope on multi-criteria decision making problems. Section 3 describes the methodology and the solution procedure. In this section, the ANP method is explained in detail which is utilized to resolve the selection problem of best laptop for educational purpose as a case. Section 4 represents summarized findings of this study and Section 5 depicts the conclusions of the study.

2. Literature Review

Previous studies on ANP method have focused upon particular implementations of this method (MU, 2005). In order to understand the ANP, there are several elaborately worked out examples of the ANP (numbered in the hundreds) mostly developed by managers, executives, industrial engineers, mature students, and others in the US and abroad (among which are Brazil, Chile, the Czech Republic, Germany, India, Indonesia, Italy, Korea, Poland, Russia, Spain, and Turkey) who have studied and subjugated its radical concepts (Saaty, 2004). The ANP is newer and more modern than the AHP. Although a limited number of studies on this topic has made, there are only a few studies that have shown the advantages of the ANP over the AHP (Sarkis and Sundarraj, 2005):

Firstly, the Analytical Hierarchy Process (AHP) demands a precise hierarchical structure and limited relationship among factors. But, this requirement does not permit for the chance of having top-to-bottom and bottom-to-top interdependent relationships and influences among group of factors, or for interdependent relationships within a cluster of factors (Taslicali and Ercan, 2006). Studies on ANP have shown that the ANP has linear relationships among elements and permits interrelationships among elements of the cluster (Tran et al, 2004). Not

only hierarchy but also a network is provided in ANP that replaces one directional relationship with dependence and feedback (Saaty, 1999). So, it can be said that ANP is more powerful technique than AHP in the decision making environment with a number of uncertainty and dynamics.

Secondly, the ANP appears rank reversion problem and so it is more precise and advantageous (than the AHP) as a decision support instrument for intricate (or more complicated) situations. For an example, in Information Strategy (IS) selection problems if the aims of information strategy applications have been identified, the optimal candidate projects decisions can be prepared by simply applying the AHP to the problem. But, in the varying environment having a lot of uncertainty and dynamics, the decision objectives associate with other elements obscurely that cannot be identified easily. In such case, ANP comes for rescuing (Tran et al, 2004).

Lastly, another problem that occurs in AHP is order change. The change of alternative priorities when a new alternative is added or subtracted is referred as order change. This problem can be eliminated by using the ANP that is indicating an appropriate decision making method for supplier selection problems among the possible potential MCDM methods.

The uncertainty and haziness of the experts' opinion is the prominent characteristic of the selection problem, this impreciseness of human's judgments can be controlled through the fuzzy sets theory (Ayhan, 2013). Fuzzy ANP method systematically solves the selection problem that uses the concepts of fuzzy set theory and networking structure analysis.

Over the years, the ANP has been applied in a variety of computer science and information technology areas for determining and selecting. Srichetta and Thurachon (2012) applied Fuzzy Analytic Hierarchy Process to Evaluate and Select Product of Notebook Computers. In this research Fuzzy is used to remove the uncertainty of the decision maker but if they used ANP in the place of AHP then they can mitigate the networking problem of the criteria. In 2007, Islklar and Buyukozkan used Multi-criteria Decision Making Approach to evaluate Mobile Phone alternatives. Dagdeviren and Yuksel (2007) had applied ANP for Personnel selection. Eddie et al (2004) used the analytic network process for Contractor selection. Meade and Sarkis (1998) in two of their studies used ANP to evaluate logistic strategies and to improve production speed. Fong and Choi (2000) had implemented the analytical hierarchy process for final contractor selection. In their study they don't consider the influencing or networking problem. MU (2005) used ANP in the Non-Profit Sector: Selecting a Congress Site and Predicting Conference Attendance. Sarkis and Sundarraj (2005) had evaluated a Decision Model for High-Level Consideration of Strategic and Operational Issues. Tran et al (2004) had made Integrated Environmental Assessment of the Mid-Atlantic Region with Analytical Network Process. This study will remove all the gaps of the previous research by employing ANP that determines the relative importance of the decision criteria or sub-criteria and their inter-relationship in order to eventually select the best Laptop for educational purpose.

The idea of influence refers as a force that produces change or disorder or chaos in central decision making. In the physical world (e.g. gravitational pull) in biology (giving birth or dying) in psychology (loving and hating) in politics (persuading, negotiating and opposing) and in every conjecturable demesne of the world it is a common term in which we live and the society in which we participate. In process thinking, change is known to be the most fundamental process in nature (Saaty, 2004). When a decision is made to select a laptop for educational purpose all the potential influences are needed to look at and not simply the influences from top to bottom or bottom to top as in a hierarchy. In the situation of laptop selection influences

spread as in a network or even more generally as in a manifold. The statement of problem of this study shows that the criteria of this problem form a network among them. This problem is not answered previous because it is more meaningful for all to understand decisions mathematically in the discrete form of the spread of influence rather than as continuous processes.

3. Methodology

There are many well-known methods for decision making but among these MCDM is relatively new to be employed to select Laptop for educational purpose. Analytical Hierarchy Process (AHP) and Analytical Networking Process (ANP) are MCDM tools. The AHP is a multi-criteria decision making tool using to take best decisions among the alternatives. The ANP is a generalization of the AHP which is an inclusive and judgmental multi-purpose decision method has been widely used solving complicated decision making problems (Saaty, 1996). The MCDM tools are first developed by one of the pioneers of Operations Research Thomas Saaty in the late 1960's. There are a lot of decision making methods that assist the decision maker selecting the best decision under situations characterized for having more than one criterion (i.e., multiple-criteria). However, there are few studies about the challenge of selecting the best decision making method for a specific situation specifically in decision making situation that take into consideration multiple criteria (Taslicali and Ercan, 2006).

3.1 Why ANP?

Although AHP represents a framework containing unidirectional hierarchical correlation, ANP allows for complex interrelationships or dependencies among decision levels and attributes. The ANP feedback method is a networking approach which interchanges hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominated or being dominated, directly or indirectly (Meade and Sarkis, 1999; Dagdeviren and Yuksel, 2007). However, ANP organizes not only the importance of the criteria as in a hierarchy but also the importance of the alternatives may have impact on the importance of the criteria (Saaty, 1996). Therefore, a hierarchical structure having a linear top-to-bottom arrangement is not applicable for a complex system (Dagdeviren and Yuksel, 2007). The mathematical calculation of AHP and ANP are almost same. But, a 'Supermatrix' is formed in ANP that will not done in AHP.

3.2 Data Collection and the Process of ANP

This investigation requires a data that need to compute the comparison matrix of the criteria. For collecting data, survey method is used in this study because this study mainly focuses on the customer's choices or priority. We have surveyed around 200 students of Rajshahi University of Engineering and Technology (Bangladesh) because they face the problem of choosing best laptop when they want to buy a laptop for their educational purpose. The survey was done by asking questions to the students. In response, they have commented their percentage of importance of the criterion. The response rate of the students is above 90%. If the response rate of the survey data is below 80% then this study will not be carried out. Finally, a primary data was collected by survey method that is provided below in the Table 1.

Table 1: Survey data collected from the Student of RUET, Rajshahi, Bangladesh (From 15 February to 20 April, 2015)

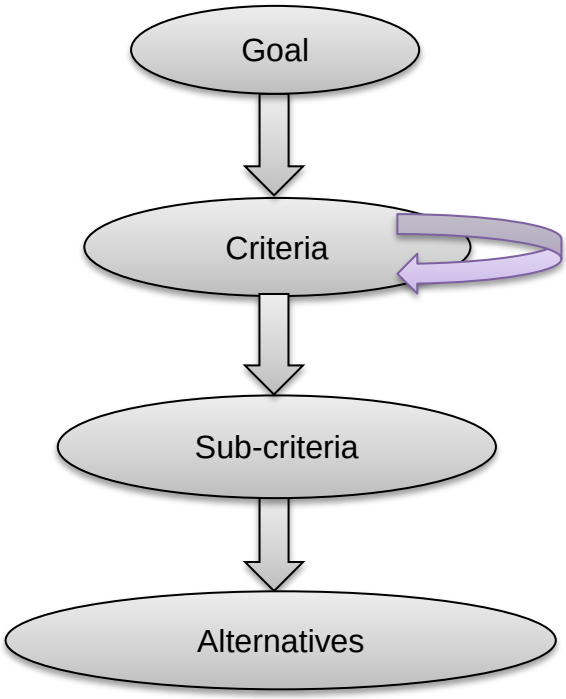
No.	Criteria	Number of Student who select the criterion as their first choice	Percentage (%) of importance	Priority weight based on Precent (%) importance
1.	Price	07.00	03.50	1.00
2.	Processor	48.00	24.00	7.00
3.	Hard Drive	35.00	17.50	5.00
4.	Graphics and Design	21.00	10.50	3.00
5.	Warranty	35.00	17.50	5.00
6.	Portable Size	20.00	10.00	3.00
7.	Battery Life	34.00	17.00	5.00
		Sample Size = 200.00	Total % = 100.00	Total = 29.00

The process of ANP consists of four major steps (Chung et al, 2006):

Step 1: Problem Structuring

A clear statement of the problem should be prepared and the problem is decomposed into a rational system like a network. The structure can be attained by incorporating the opinion of decision makers through brainstorming or other appropriate methods (Meade and Sarkis, 1998). An example of the format of a network is as shown in Figure 1.

Figure 1: Networking of the Criteria



Step 2: Pairwise Comparisons Matrices and Priority Vectors

Like AHP, in ANP decision elements at each component are pairwise compared with respect to their importance near their control criterion. Moreover, the components are also compared themselves pairwise with respect to their contribution to the goal. Decision makers are asked to respond to a series of pairwise comparisons where two elements or two components at a time will be compared in terms of how they contribute to their particular upper level criterion (Meade and Sarkis, 1999). In addition, if there are interdependencies or relationships among elements of a component, pairwise comparisons also need to be formed and an eigenvector can be attained for each element to show the influence of other elements on it (Dagdeviren and Yuksel, 2007).

The standard way of a pair-wise comparison is to offer experts to compare two sub-cluster's elements with respect to their respective cluster's element. A 9-point priority scale of measurement has developed by Saaty (1980) in which a score of 1 representing equal importance of the two compared elements and 9 being overwhelming dominance of one element (row element) over another element (column element). Saaty's 1-9 scale is given in Table 2.

Table 2: Saaty's 1-9 Scale for AHP Preference (Yurdakul, 2003; Cheng and Li, 2001)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance	Experience and judgment slightly favour one over another.
5	Strong importance	Experience and judgment strongly favour one over another.
7	Very strong importance	Activity is strongly favoured and its dominance is demonstrated in practice.
9	Absolute importance	Importance of one over another affirmed on the highest possible order.
2,4,6,8	Intermediate values	Used to represent compromise between the priorities.

In this paper, the following three-step procedure is used to synthesize priorities and they are

- Evaluating a single pair-wise comparison matrix depending on their relative importance for the criteria;
- Normalizing the every single column of the matrix and calculating appropriate weights or priorities;

- Calculating and checking the Consistency Ratio (CR) of the matrix. If the CR is less than 0.1 (10%), the pairwise comparison is accepted otherwise the comparison matrix will be rejected. The consistency ratio (CR) is calculated by the following formula;

$$\mathbf{CR} = \frac{\mathbf{CI}}{\mathbf{RI}} \qquad (\mathbf{1})$$

Here, **CI =** Consistency index **=** $\frac{Eigen\ value - n}{n-1}$
And, n = the number of criteria is used in the problem.

The value of Random consistency **(RI)** index is taken from the Table 3 is given below:

Table 3: Value of random consistency index RI (Saaty, 1980)

Criteria, n	3	4	5	6	7	8	9	10
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Step 3: Super Matrix Formation

The concept of supermatrix is similar to the Markov chain process. The global priorities in a system with interdependent influences are obtained and the local priority vectors are entered in the appropriate columns of a matrix (Dagdeviren and Yuksel, 2007). For this reason, a supermatrix where each matrix segment represents a relationship between two nodes (components or clusters) in a system is really a partitioned matrix (Meade and Sarkis, 1999). Consider, the components of a decision system are C_k, k=1, 2… n, and each component k has m_k elements denoted by e_{k1}, e_{k2}… e_{kmk}. The local priority vectors that are obtained in step 2 are grouped and positioned in appropriate places in a supermatrix based on the flow of influence from a component to another component or from a component to itself as in the loop. A standard form of a supermatrix is given below (Saaty, 1996).

Figure 2: Standard form of a Supermatrix

$$\mathbf{W} = \begin{array}{c} \\ C_1 \\ \\ \\ C_k \\ \\ \\ C_n \\ \\ \end{array} \begin{array}{c} \begin{array}{cccccccccccccc} C_1 & & & & C_k & & & & C_n & & & \end{array} \\ \begin{array}{cccccccccccccc} e_{11} & e_{12} & \cdots & e_{1m1} & \cdots & e_{k1} & e_{k2} & \cdots & e_{k\,mk} & \cdots & e_{n1} & e_{n2} & \cdots & e_{n\,nn} \end{array} \\ \begin{bmatrix} W_{11} & \cdots & W_{1k} & \cdots & W_{1n} \\ \vdots & & \vdots & & \vdots \\ W_{k1} & \cdots & W_{kk} & \cdots & W_{kn} \\ \vdots & & & & \vdots \\ W_{n1} & \cdots & W_{nk} & \cdots & W_{nn} \end{bmatrix} \end{array}$$

Step 4: Formation of Limit Matrix and Selection of Best Alternatives

The supermatrix is used to compute the 'Limit Matrix'. The matrix is found by multiplying the supermatrix by itself numerical times. And this multiplication will be stopped when the final matrix appears same value in each row. This final matrix is called Limit matrix. This Limit

matrix is also known as the Weighted Supermatrix, because all the elements in each row are same and the sum of the final priority of all alternatives is equal to 1 (one).

3.3 Problem Structure and Solution

In our present case study, the hierarchical structure of Fong and Choi (2000) has showed by adding interdependent influences at the selection criteria level. The original hierarchical structure of the problem has been constructed that composed of four levels illustrate in the Figure 3. In this structure the decision problem is on the top of the structure. Then the problem is divided into some criteria that are given in the middle section of the problem. The best laptop is selected based on these criteria. Finally, the bottom level comprises the four decision alternatives (i.e. four laptops). Figure 4 demonstrates a general view of networking that shows the dependencies among the criteria. Actually, this is the main part of ANP that is not considered in the AHP. This networking structure mainly differs from the original hierarchical by the feedback loop in the selection criteria level. It is appeared that the seven selection criteria are interdependent, i.e. these criteria have interrelationship and that is shown by the networking in figure 4.

Figure 3: Hierarchical structure of Laptop selection

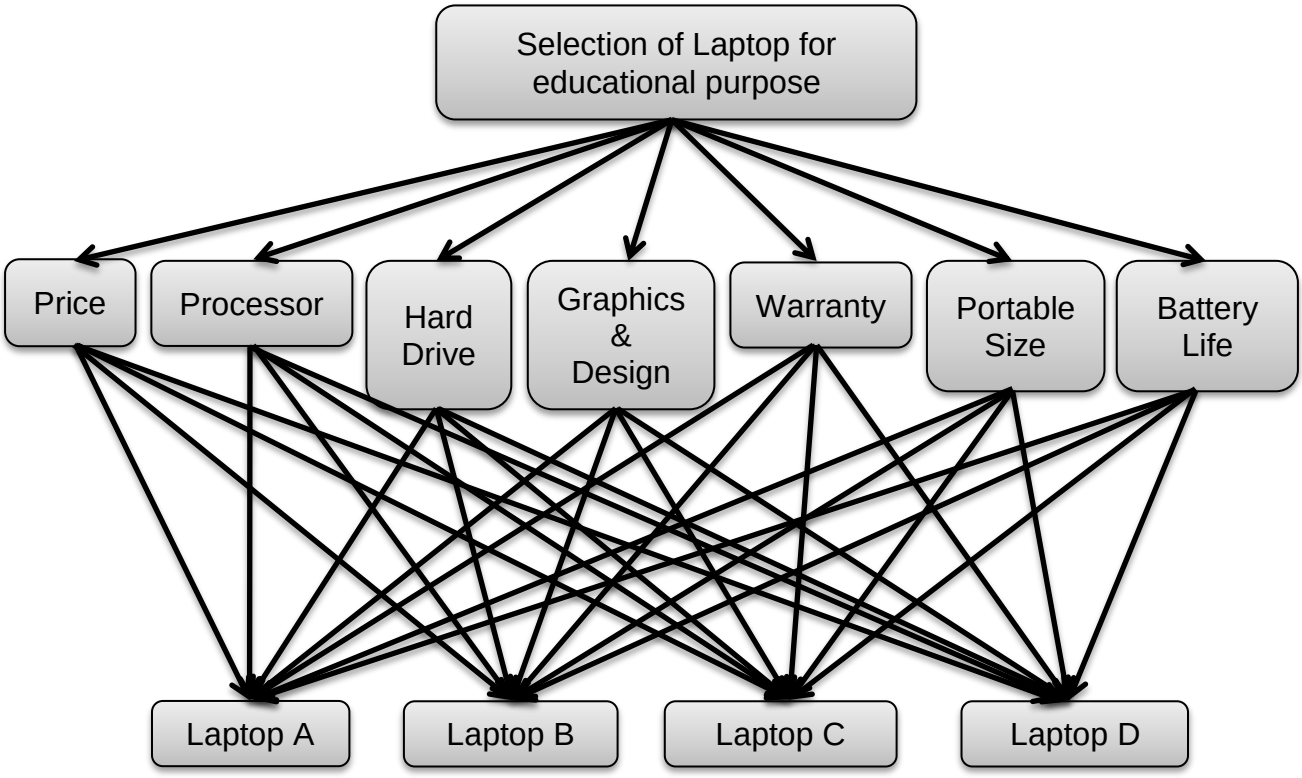
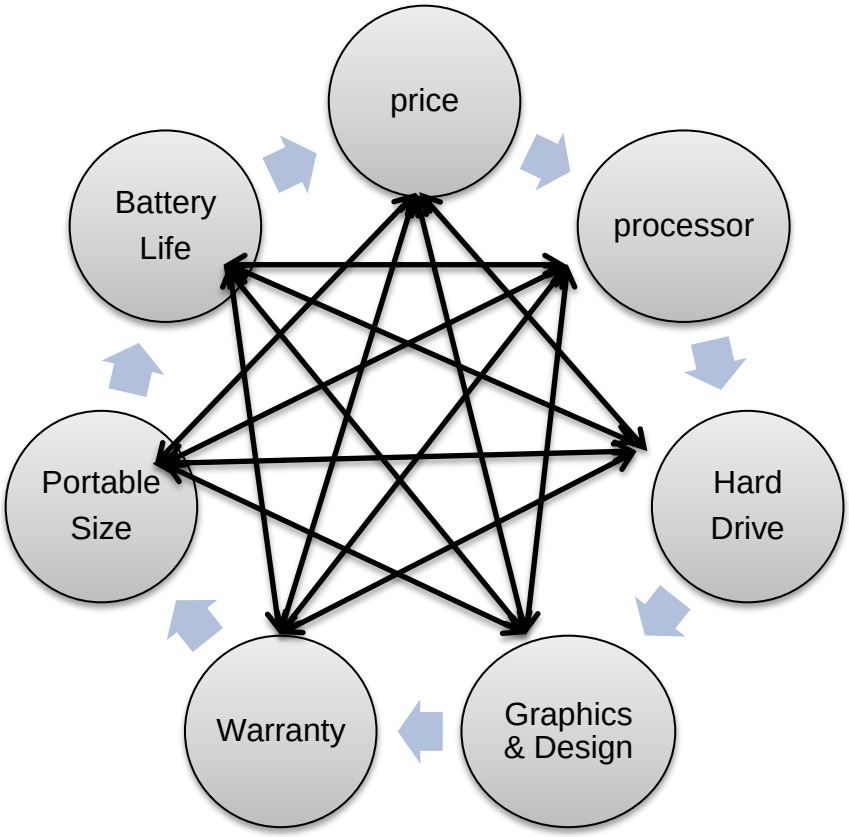


Figure 4: Networking of the criteria



3.3.1 Pairwise Comparisons

The general technique of a pair-wise comparison is to compare two sub-cluster's elements with respect to their respective cluster's element (Eddie et al, 2004). Pairwise comparisons will be made for indicating the relative amount of importance and influence that flows from one element to each of the other elements (Bauyaukyazc and Sucu, 2003). The priority weight gives the priority indices for the criteria. The pairwise comparisons of the criteria in terms of their relative importance values along with column totals are shown in the table 4 below:

Table 4: Matrixes of Pairwise Comparisons of Criteria along with Column Totals

Goal	Price	Processor	Hard Drive	Graphics and Design	Warranty	Portable Size	Battery Life
Price	1	1/7	1/5	1/3	1/5	1/3	1/5
Processor	7	1	2	4	2	4	2
Hard Drive	5	½	1	2	1	2	1
Graphics and Design	3	¼	½	1	½	1	½
Warranty	5	½	1	2	1	2	1
Portable Size	3	¼	½	1	½	1	½
Battery Life	5	½	1	2	1	2	1
Total	29	22/7	31/5	37/3	31/5	37/3	31/5

Table 4 shows the comparison matrix among the criteria in which the scale 1 to 9 refers their relative importance of the criteria. Furthermore, Table 4 illustrates that Processor criterion is 7 times important than Price criterion, Hard Drive criterion is 5 times important than Price criterion and other criterion also depicts their importance.

Table 5: Normalized Weights of Matrix of Pairwise Comparisons of Criteria with Priority Weight (Vector weights)

Goal	Price	Processor	Hard Drive	Graphics and Design	Warranty	Portable Size	Battery Life	Priority Weight
Price	1/29	1/22	1/31	1/37	1/31	1/37	1/31	0.032
Processor	7/29	7/22	10/31	12/37	10/31	12/37	10/31	0.311
Hard Drive	5/29	7/44	5/31	6/37	5/31	6/37	5/31	0.163
Graphics and Design	3/29	7/88	5/62	3/37	5/62	3/37	5/62	0.084
Warranty	5/29	7/44	5/31	6/37	5/31	6/37	5/31	0.163
Portable Size	3/29	7/88	5/62	3/37	5/62	3/37	5/62	0.084
Battery Life	5/29	7/44	5/31	6/37	5/31	6/37	5/31	0.163
Total	1	1	1	1	1	1	1	1

Consistency ratio = 0.00116 < 0.1

Table 5 represents the normalized weight of the comparison matrix of Table 4. It also shows the relative priority weight of each criterion that was given in the last column of the table. The consistency ratio (CR) is 0.00116 < 0.1 indicates that the comparison matrix of table 4 is accurate.

Check for Consistency of values in the priority weight of criteria of Table 5:

Eigen value = 7.0092

Consistency index (**CI**) **=** $\frac{Eigen\ value - n}{n-1}$

= (7.0092-7) / (7-1)

= 0.00153

Random Consistency index (**RI**) = 1.32 for criteria, n = 7

Consistency ratio (**CR**) **= CI / RI =**0.00153 / 1.32 = 0.00116 < 0.1

Table 6: Normalized Weights of Matrix of Pairwise Comparisons of Criteria with Respect to Price With Priority Weight (Vector Weights)

Price	Processor	Hard Drive	Graphics and Design	Warranty	Portable Size	Battery Life	Priority weight
Processor	15/46	3/8	1/3	2/7	1/3	3/8	0.338
Hard Drive	5/46	1/8	2/15	1/7	2/15	1/8	0.128
Graphics and Design	3/46	1/16	1/15	1/14	1/15	1/16	0.066
Warranty	15/46	¼	4/15	2/7	4/15	¼	0.274
Portable Size	3/46	1/16	1/15	1/14	1/15	1/16	0.066
Battery Life	5/46	1/8	2/15	1/7	2/15	1/8	0.128
Total	1	1	1	1	1	1	1

Consistency ratio = 0.00379 < 0.1

Table 6 represents the normalized weights of matrix of pairwise comparisons of criteria with respect to price with Priority weight. Before making this table Price criterion becomes constant and based on this criterion the other criterion are compared to each other. To calculate the priority of each criterion the comparison table is normalized. The consistency ratio of this table is 0.00379 < 0.1 which indicates that the table is consistent (accurate).

Table 7: Normalized Weights of Matrix of Pairwise Comparisons of Alternatives with Respect to Price with Priority Weight

Price	Laptop A	Laptop B	Laptop C	Laptop D	Priority
Laptop A	1/16	2/37	1/22	4/53	0.059
Laptop B	5/16	10/37	3/11	14/53	0.280
Laptop C	3/16	5/37	3/22	7/53	0.148
Laptop D	7/16	20/37	6/11	28/53	0.513
Total	1	1	1	1	1

Consistency ratio = 0.0134 < 0. 1

Table 7 illustrates the comparison of alternatives with respect to Price criterion. The 1st, 2nd, 3rd and 4th column represents the normalized weight of each alternative. The priority weight of each alternative is included in the last column of the table which give idea about their importance with respect to Price criterion. The consistency ratio 0.0134 < 0.1 indicates that the comparison table is accurate.

3.3.2 Supermatrix Formation

A system having interdependent influences and consisting of cluster and sub-cluster matrices must translate to a supermatrix. For obtaining this the local priority vectors must be entered in the supermatrix (Eddie et al, 2004).By doing this the global priorities will be achieved in turn

finally. The supermatrix that has formed contains 14 rows and 10 columns. This supermatrix is shown in Table 8 for the ANP model.

Table 8: The Supermatrix (Constructed by using the Priority Vectors)

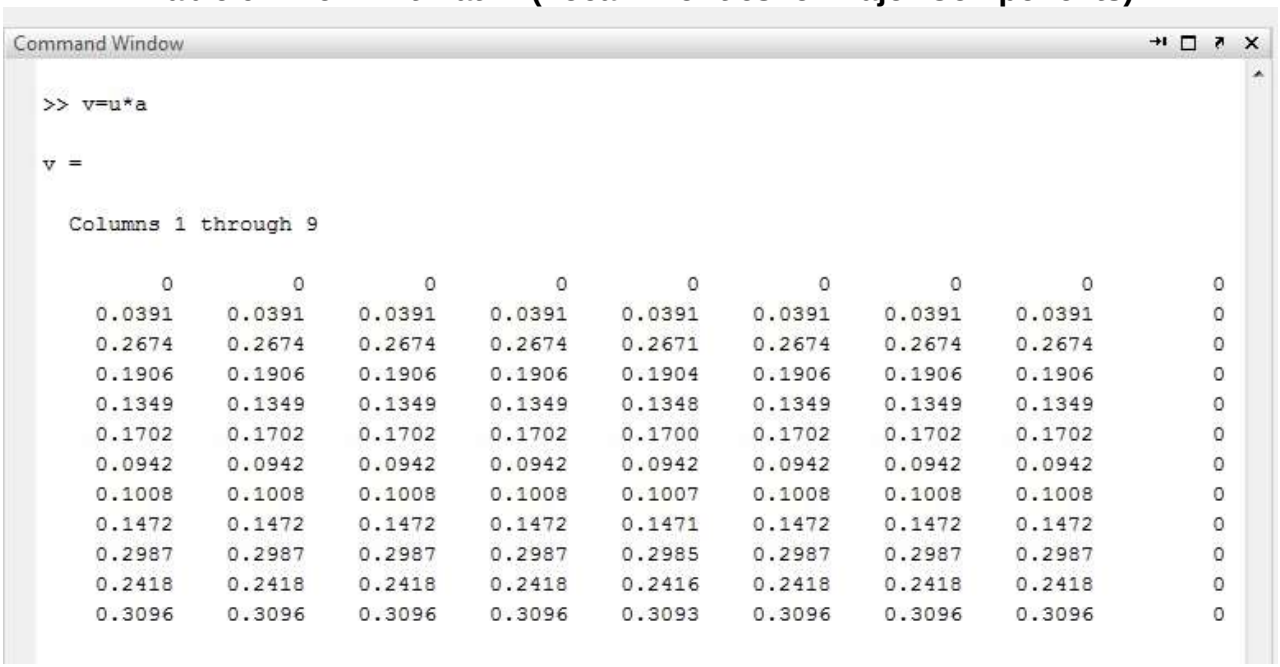
			Selection Criteria						
		Goal	Price	Processor	Hard drive	Graphics and Design	Warranty	Portable Size	Battery Life
	Goal	0	0	0	0	0	0	0	0
Selection Criteria	Price	0.032	0	0.050	0.040	0.031	0.040	0.039	0.034
	Processor	0.311	0.338	0	0.368	0.426	0.368	0.369	0.289
	Hard Drive	0.163	0.128	0.268	0	0.246	0.195	0.195	0.289
	Graphics and Design	0.084	0.066	0.138	0.195	0	0.195	0.101	0.154
	Warranty	0.163	0.274	0.268	0.195	0.124	0	0.195	0.154
	Portable Size	0.084	0.066	0.138	0.101	0.076	0.101	0	0.080
	Battery Life	0.163	0.128	0.138	0.101	0.096	0.101	0.101	0
Alternatives	Laptop A	0	0.059	0.059	0.043	0.524	0.043	0.392	0.059
	Laptop B	0	0.280	0.148	0.513	0.158	0.513	0.144	0.280
	Laptop C	0	0.148	0.513	0.159	0.096	0.159	0.144	0.148
	Laptop D	0	0.513	0.280	0.285	0.222	0.285	0.320	0.513

Table 8 represents a supermatrix in which element of a row or column is rounded to three decimal places. The priority weights derived from pairwise comparison matrices (Table 4, 5, 6) have entered as a part of some column of a supermatrix. The supermatrix describes the influence priority of an element on the left of the matrix on an element at the top of the matrix.

3.3.3 Computation of Limit Matrix and Selection of best Laptop

The supermatrix that is formed contains the weights or priorities for the final judgment matrices. The column stochastic is completed and the supermatrix is then elevated to sufficient large power until convergence occurs (Saaty, 1996; Meade and Sarkis, 1998). The limit matrix is founded by multiplying the supermatrix by itself 21(twenty one) times. Table 9 represents the final limit matrix. Each row contains the same value and provides the final priorities or weights for the alternatives and criteria.

Table 9: The Limit Matrix (Local Priorities for Major Components)



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Command Window

>> v=u*a

v =

  Columns 1 through 9

         0         0         0         0         0         0         0         0         0
    0.0391    0.0391    0.0391    0.0391    0.0391    0.0391    0.0391    0.0391         0
    0.2674    0.2674    0.2674    0.2674    0.2671    0.2674    0.2674    0.2674         0
    0.1906    0.1906    0.1906    0.1906    0.1904    0.1906    0.1906    0.1906         0
    0.1349    0.1349    0.1349    0.1349    0.1348    0.1349    0.1349    0.1349         0
    0.1702    0.1702    0.1702    0.1702    0.1700    0.1702    0.1702    0.1702         0
    0.0942    0.0942    0.0942    0.0942    0.0942    0.0942    0.0942    0.0942         0
    0.1008    0.1008    0.1008    0.1008    0.1007    0.1008    0.1008    0.1008         0
    0.1472    0.1472    0.1472    0.1472    0.1471    0.1472    0.1472    0.1472         0
    0.2987    0.2987    0.2987    0.2987    0.2985    0.2987    0.2987    0.2987         0
    0.2418    0.2418    0.2418    0.2418    0.2416    0.2418    0.2418    0.2418         0
    0.3096    0.3096    0.3096    0.3096    0.3093    0.3096    0.3096    0.3096         0
```

Table 9 represents a limit matrix in which every element of a row has the same value. A higher order matrix multiplication is quite complicated which can't be done in Microsoft Excel. So, the MATLAB software is used to compute the limit matrix. In the last four rows of this limit matrix (table 9), the limiting priorities or weights of the four laptop alternatives is appeared. The priorities of 0.1472, 0.2987, 0.2418, and 0.3096 are for Laptop A, Laptop B, Laptop C and Laptop D respectively. Finally, Laptop D is selected for educational purpose because it has more priorities than others.

4. Analysis of Results

This study incorporates the ANP technique for selecting the best Laptop for educational purpose. The main objective of utilizing the ANP tool is to find out the best laptop alternatives. To solve this problem a new networking structure (Figure 4) among the criteria has been built which represents the influences of each criterion to another criterion. This paper attempts to provide a decision support system that helps the decision maker to take the right decision in the situation of inter-dependency of the criterion. Relative weights are computed and tabulated in section 3. By implementing the ANP tool the optimal alternative is found having the largest priority 0.3096 for Laptop D. So, Laptop D is the first best Laptop and Laptop B is the second best laptop having priority 0.2987. If the Laptop D is not available in the market then Laptop B can be selected. From this study, it can be concluded that findings of this study is consistent because the sum of the final priority is equal to 1 (one). If the sum of the final priority is not equal to 1 then this study will become an unacceptable study. The final outcome of ANP method is tabulated below in table 10.

Table 10: Final Priorities for the Alternatives and Selection of the Best Alternative

Alternatives	Final Priority	Decision
Laptop A	0.1472	Fourth best
Laptop B	0.2987	Second best
Laptop C	0.2418	Third best
Laptop D	0.3096	First best (Selected)
Total	1.0000	

Table 10 depicts the final priority or final results of this investigation. This table also gives idea about the best laptop that a student can buy for his educational purpose. The 3rd column of the table represents the best decision about the best laptop alternative.

5. Conclusions

The selection of laptop by using Analytical Networking Process is a new application of ANP in multi-criteria decision making situation. When studying about the ANP we have known how this ANP tool works and how it applies in a complicated decision making situation. When choosing the criteria for purchasing a laptop, the demandable customers' requirements are also identified because customers looking for additional or attractive features. When we went to different types of people to know about their requirements for selecting a laptop for educational purpose, we have known their mostly wanted requirements and features. Then based on their requirements the criteria's are selected and compared. Mostly demandable requirements are given more importance when constructing the comparison matrices. By doing such kind of field work, a huge information and knowledge about the marketing side are also gathered. Finally, this analysis helps us to select a laptop according to the customers' requirements for educational purpose. The final result of this investigation is fully different from the previous studies because a new networking structure is provided in this study. Moreover, the criteria that are utilized to develop a new networking structure are also different from the previous study and this is the main reason to obtain a new result. This study will help us when we want to buy a laptop for educational purpose. The significance of this study can't be expressed in a word because the decision support system that is provided in this study will help the decision maker to mitigate their real life decision making problem in future. However, in this study, ANP method is utilized for the multi criteria decision making problems, other decision making techniques like fuzzy ANP, technique for order preference by similarly to ideal solution (TOPSIS), weighted sum model (WSM), SWOT ANP etc. can also be utilized and compared with acquired results. The limitation of this investigation is that the proposed decision support system will use only for laptop selection for educational purpose. The proposed decision support system can't involve any sub-criteria of the criterion. By including more criterion and sub-criterion, this proposed decision support system can be reformed in future for other applications.

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