Research Journal of Engineering Sciences ISSN 2278 – 9472
Vol. **2(2),** 38-46, February **(2013)** *Res. J. Engineering Sci.*

Review Paper

Investigations on Criteria Evaluation and Selection Method of Internet Service Providers for e-manufacturing: A Case study

Rama Rao A.[1] and Indira P.M.[2]
[1]Dept. of Mechanical Engg, PACE institute of technology and sciences, Ongole, INDIA
[2]Dept. of Computer Science and Engg, PACE Institute of Technology and Sciences, Ongole, INDIA

Available online at: www.isca.in
Received 17th January 2013, revised 9th February 2013, accepted 18th February 2013

Abstract

In supplier selection decisions two issues are of particular significance. One is what criteria should be used and other, what methods can be used to compare suppliers. In real world, the criteria, constraints for supplier selection process are subjective in nature and with an emerging application of internet and tether-free communication technologies; e-intelligence is forcing companies to shift their manufacturing operations rapidly from the traditional factory-integration philosophy to e-manufacturing philosophy. Thus researchers and managers of firms should see the need to evaluate the fitness of supplier selection criteria and methods when applied to newly created enterprises to ensure effective and profitable exploitation of market opportunities. Hence in the current research an attempt is made to investigate the criteria to be considered and methods for prioritization best Internet Service Provider for e-manufacturing. The proposed model is tested with correlation test as well as hypothesis to see the validation of the proposed methodology.

Keywords: Bell-shape fuzzy membership function, E-manufacturing, hierarchical fuzzy TOPSIS, internet service provider (ISP), prioritization of suppliers.

Introduction

For the past decade, the impact of web-based technologies added velocity to the design, manufacturing, and aftermarket service of a product. Today's competition in manufacturing industry depends not just on lean manufacturing, but also on the ability to provide customers with total solutions and life-cycle costs for sustainable value and thus manufacturers are now under a tremendous pressure to improve their responsiveness and efficiency in terms of product development, operations, and resource utilization with a transparent visibility of production[1]. With an emerging application of internet and tether-free communication technologies, the impact of e-intelligence is forcing companies to shift their manufacturing operations from the traditional factory-integration philosophy to an e-factory and other wise called e-manufacturing philosophy. In the current work an attempt is made to evaluate the criteria to be considered and methods for the selection of Internet Service Providers (ISPs) in the context of e-manufacturing, because firm's environments affect the decisions; the researchers and managers of firms should see the need to evaluate the fitness of ISPs selection criteria and methods when applied to newly created enterprises of e-manufacturing. Since internet based businesses have grown rapidly 1995, selection criteria is changed with a great deal, corresponding to the business environmental changes. Thus to meet requirements of e-manufacturing, ISPs criteria evaluation and selection method, Multi Criteria Decision Models (MCDM) have been reviewed and in spite of many MCDM models, TOPSIS method is being a popular approach was widely used in the literature for vendor selection[2]. Differing from earlier research, current research proposes an Interdependency Criteria Clusters and QFD in Hierarchical fuzzy TOPSIS for evaluation of ISPs for M/S GANGADEEP INDUSTRIES, Bangalore, and using Phi-fuzzy membership function to address the uncertainty in ISPs selection process for newly evolved firms like E-manufacturing firms. To enable the 'voice' of stakeholders', an approach should be developed to select suppliers strategically[3]. Specifically, multiple criteria are derived from the requirements of firm's stakeholders. The most important information, that the QFD provides the importance weightings of evaluating criterion which are derived by the importance ratings. Nevertheless the proposed approach has not been applied to the ISPs selection problem yet. Finding the issues of e-manufacturing through the available literature, this research reveals the e-manufacturing characteristics and capabilities compared to traditional manufacturing and the issue of prioritization ISPs in the conjunction with e-manufacturing with a new framework.

e-Manufacturing System

e-Manufacturing is a transformation system that enables the manufacturing operations to achieve predictive near-zero-downtime performance as well as to synchronize with the business systems through the use of web-enabled and tether-free (i.e., wireless, web, etc.) technologies. It integrates information and decision-making among data flow (of machine/process level), information flow (of factory and supply system level), and cash flow (of business system level) and hence e-Manufacturing is a business strategy as well as a core competency for companies to compete in today's e-business environment[4]. It is aimed to complete integration of all the elements of a business including suppliers, customer service network, manufacturing enterprise, and plant floor assets with connectivity and intelligence brought by the web-enabled and tether-free technologies and intelligent computing to meet the demands of e-business/e-commerce practices that gained great acceptance and momentum over the last decade. Also, e-Manufacturing is a transformation system that enables e-Business systems to meet the increasing demands through tightly coupled supply chain management (SCM), enterprise resource planning (ERP), and customer relation management (CRM) systems as well as environmental and labor regulations and awareness. Thus e-Manufacturing allows geographically separated manufacturers to build partnerships so as to embrace external resources and services without owning them. Though web technology seems to promise in early explorations, most of the presently developed e-manufacturing systems are still prototypes for studying the feasibility and potential of web technologies in advanced manufacturing, where every aspect becomes a vital part, more particularly suppliers, and participates into the enterprise-wide profit process[5]. As, e-manufacturing is different from traditional manufacturing by its characteristics, the criteria to be considered as well as the supplier selection methods are to be reviewed. It is found in the literature that no researcher pointed out the issue of supplier selection criteria and methodology in the context of e-manufacturing. As e-manufacturing is rapidly developing arena for the past decade, and to cope up to the issues pertaining to e-manufacturing criteria and supplier evaluation methods, an attempt is made in the current research.

ISPs Selection

In this research a novel model for ISPs selection which can be applied for most of the upcoming e-manufacturing firms. In addition, most published models in this area focus only on the customer perspective or supplier's performance perspective. Traditionally organizations have been divided in operative functions such as production, planning, purchasing, marketing etc., in which supply chain is a strategy that integrates these functions, and also involved in manufacturing of a product from the procurement of raw materials to the distribution of final products to the clients. Thus purchasing commands significant position in most organizations and typically represent 40 to 60 percent of the sales of its end products and the topic of supplier selection was well focused on since 1966. Over the years the significance of supplier selection has been long recognized and emphasized. Thus one of the important purchasing decisions is the selection and maintenance of a competent group of suppliers[6]. In supplier selection decisions two issues are of particular significance. One is what criteria should be used and other, what methods can be used to compare suppliers. It is pointed out that supplier selection decisions were complicated by the fact that various criteria that must be considered and meanwhile, different approaches could be employed to make the selection[7]. The criteria delivery, quality, cost/price, financial position and communication and technology were recognized as the commonly used criteria a fact confirmed from empirical results as well as in previous literature. However other criteria such as ISO certification, reliability, credibility, good references and product development were also identified. These criteria had existed before but did not receive the same attention in previous studies. This show that focus is shifting from solely relying on quantitative factors to include qualitative criteria. Thus many authors have identified several criteria for supplier selection since 1996 as criteria are a key issue in supplier assessment process since it measures the performance of supplier. It is to be noticed that earlier scholars have paid attention towards various criteria in supplier selections with respect to different types of enterprises more particularly, in a traditional environments. However as it is believed that e-manufacturing is different from traditional manufacturing by its characteristics and capabilities and selection of suppliers as well as criteria preferences to be considered must vary. Also, there is no evidence that the earlier researchers have pointed out the issues related to the criteria and ISPs selection methods in conjunction with e-manufacturing because, different situations require the use of different models and criteria selection.

Research Method

Criteria Clusters: Clustering is concerned with grouping of objects or elements (Criteria) into homogeneous clusters (groups) based on the object features or interdependency[8]. The Interdependencies among the criteria may have an effect in the decision making process of selecting suppliers for a given firm. The current research tried to identify the existence of interdependencies and formation into clusters. The Strategic Sourcing Group (SSG) of the firm involved in evaluating the criteria clusters using the following three step procedure.

Step 1: Determining the pair wise relation: Several sets of pair wise relations are needed to make by decision making experts (SSG Team) where decision makers are asked to make the pair wise relations typically using interdependency five point scale and dependency of one criteria with another is determined in terms of numerical value and an example is shown in the table 1.

Table-1
Typical voting of a decision maker

Criteria	Speed	Web Hosting	Security	Responsiveness
Speed	---	X	-----	X
Web Hosting	X	----	X	X
Security	X	X	------	X
Responsiveness	X	X	--------	------

Step 2: Quantifying the cluster blocks: In order to present the comprehensive framework for the criteria clusters formation further quantifying pair wise relations by considering only top half of the MxM matrices and is shown in table 1.

Step 3: Formation of Clusters: In the third step the Equation 4.1 is used to determine which block of the MxM interdependency matrix is qualified to represent interdependency.

$$Q = \sqrt{N} \div 2 \quad (4.1)$$

And Q = Interdependency index, N =Total score attained from interdependency scale by the decision makers. If Q is ≥ 4.2 the block is qualified to form into cluster with respective criteria and If Q is ≤ 4.2 the block is not qualified to form into a cluster.

Where the value 4.2 is square root of the number of decision makers and in the current research the number of decision makers is 18. Thus from the above three steps, a set of pair wise comparisons between interdependent criteria is conducted in the form of questionnaire and the table 2 is prepared to form interdependency clusters. The numbers shown in the table 2 represent the total score given by eighteen decision makers while the blanked blocks express no interdependency recognized by any of the decision makers and thus identifying these interdependencies the respective clusters have been formed.

C 1 {Web Accessibility (A)
Speed (S)
Web Hosting (W) }
C2 {Responsiveness (R)
Security (S) }
C3 {Extra Services (E)
Reliability (Re)
Roaming (Ro) }

C4 {Effective Marketing and Promotion (E) Financial Strength (F)
Management Stability (M)
Technology (T) }
C5 {Experience (Ex) Network Topology (Nt) }
C6 {Installation Charges (Ic) Monthly charge (Mc) Strategic Allowances (St)
Support Resources (Su) }
C7 { Legal Taxes }
C8 {Network Links}

Methodology: Prioritization of Suppliers

Decision making or prioritization problem is the process of finding the best option from all of the feasible alternative suppliers[9]. In almost all such problems the multiplicity of criteria for judging the alternatives is pervasive.

Bell-shape fuzzy membership function: Fuzzy set theory is based on the extension of the classical definition of a set. In a classical set theory, each element of universe either belongs to a set or not, where as in fuzzy set theory an element belongs to a set within a degree of certain membership. Membership functions of fuzzy need not be symmetric and typical so-called bell-shaped membership function, which captures conception of a large number in the context of each particular application[10]. Even though there are situations in which non-linear membership functions are more suitable, most practitioners' have found that triangular and trapezoidal membership functions are sufficient for developing an approximate solutions for the problems they wish to solve but differentiable or non-linear membership functions have certain advantages in evaluating more exact solutions rather than approximate solutions[11], an attempt is made with a Phi- membership function in the current research shown in the figure 1 The behavior of Bell-shaped membership function used currently in the research is drawn and defined by the mathematical equation 1 and using the program code written in MATLAB 9.0.

Table-2
Voting of Decision makers to evaluate clusters

Criteria	A	S	W	R	Se	E	Ro	Re	PF	M	T	Ex	Nt	St	Su	Ic	Mc	Le	Nl
A	1	**80**	**70**						50				40						
S	0.012	1																	
W	0.014		1																
R				1						**75**									
Se					1										**75**				
E						1							**70**						
Ro							1					**75**						**75**	
Re								1											
PF	0.02								1										
M				0.012						1								**75**	**80**
T											1								
Ex												1							
Nt	0.025					0.014							1						
St														1					**80**
Su				0.013	0.012										1				
Ic							0.012			0.012						**1**			
Mc																	**1**		
Le																		1	
Nl									0.014						0.014				1

$$X = \begin{cases} (1+\cos(p\pi(x-r)))/2 & \text{Where } x \in [r-1/p, r+1/p] \\ 1 & \text{Otherwise} \end{cases} \quad (1)$$

Where r denotes the real number for which the membership grade is required to be one and p is parameter that determines the rate at which, for each x, the function decreases with the increasing the difference (r-x).

Thus the scale formed is shown in the table 3 and table 4 is used for criteria weighting. Each linguistic variable is defined by eleven fuzzy numbers as the Bell-shaped curve is a non linear. The range of each fuzzy linguistic variable is also given for a given scale range between 0 and 1.

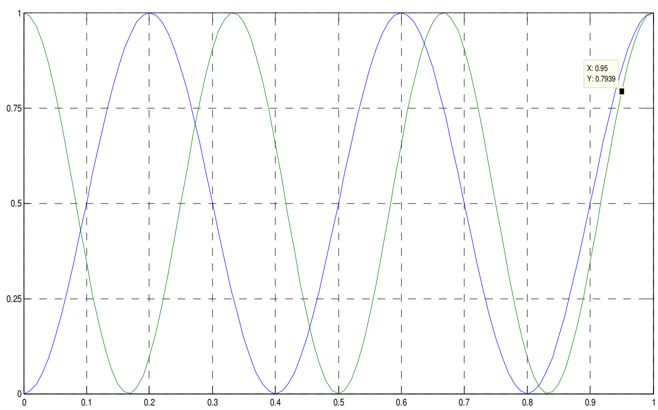

Figure-1
Bell-shaped fuzzy set with Linguistic variables

Table-3
Linguistic Scale for Criteria weights

Linguistic Scale	Range
Very Low	0 to 0.17
Low	0 to 0.4
Medium Low	0.17 to 0.5
Medium	0.4 to 0.8
Medium High	0.5 to 0.84
High	0.8 to 1
Very High	0.84 to 1

Table-4

Fuzzy	Linguistic Variables
Very High	0.84,0.89,0.92,0.95,1,1,1,1,1
High	0.8,0.87,0.9,0.93,1,1,1,1,1
Medium High	0.5,0.55,0.58,0.61,0.67,0.72,0.75,0.84
Medium	0.4,0.47,0.5,0.53,0.6,0.67,0.7,0.73,0.8
Medium Low	0.17,0.22,0.25,0.28,0.3,0.330.39,0.42,0.45,0.5
Low	0,0.07,0.1,0.13,0.2,0.27,0.3,0.33,0.4
Very Low	0,0,0,0,0,0.06,0.08,0.11,0.17

Proposed methodology with Hierarchical Fuzzy TOPSIS Algorithm: TOPSIS method is a Technique for Order Preference by Similarity to Ideal Solution, one of the known classical Multi Criteria Decision Making (MCDM) methods. It is based upon the concept that the chosen alternative should have the shortest distance from Positive Ideal Solution (PIS)[12]. The PIS solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the Negative Ideal Solution (NIS) also called anti-ideal solution, which maximizes the cost criteria and minimizes the benefit criteria. The so-called benefit criteria are those for maximization, while the cost criteria are those for minimization. The best alternative is the one, which is the closest to the ideal solution and farthest from the negative ideal solution. However the classical TOPSIS methods do not have a hierarchical structure and the only method that considers the hierarchy between criteria and sub-criteria is analytic hierarchy process (AHP). Hierarchical fuzzy TOPSIS algorithm is used in the current research and in addition interdependency Criteria clusters are used. The following steps have been used to implement the Hierarchical fuzzy TOPSIS.

Step 1: Identification of Criteria: Choosing proper criteria for supplier selection is the prior step i.e., Evaluation of Criteria for ISPs selection in conjunction with e-manufacturing characteristics and capabilities.

Step 2: Calculation of Weights of Criteria: While calculating weights of criteria, assume that $\tilde{w}_i$ the weight of i^{th} criteria in clusters and $\tilde{w}_{ij}$ is the weight of j^{th} sub- criteria of its associated criteria[13]. Final weight of each sub-criterion is calculated separately, by multiplying these two kinds of weights as shown in equation 2, where k =1, 2... m and $\boldsymbol{m}$ is the number of all sub-criteria.

$$\tilde{W}_k = \tilde{w}_i * \tilde{w}_{ij} \quad (2)$$

As in the current research Bell-shaped membership function is used the fuzzy weights are shown in equation 3.

$$\tilde{w}_i = (\alpha_{1j}, a_{2j} \ldots\ldots\ldots\ldots, a_{11j}) \quad \text{and}$$
$$\tilde{w}_{ij} = (\alpha'_{1i}, a'_{2i} \ldots\ldots\ldots\ldots, a'_{11i}) \quad \text{Then}$$
$$\tilde{W}_k = (\alpha_{1j}, a_{2j} \ldots a_{11j})\,(\alpha'_{1i}, a'_{2i} \ldots\ldots, a'_{11i})$$
$$= (\alpha_1 i\, \alpha'_{1j}, a_{2i}\, a'_{2j}, \ldots\ldots, a_{11i}\, a'_{11j}) \quad (3)$$

Step 3: Computation of Final Score: Calculation of final score for prioritization of suppliers consists of the decision makers to evaluate potential suppliers based on fuzzy TOPSIS method and defined clustered criteria. First a decision matrix, D, of dimension $\boldsymbol{n*m}$ is defined where x_{ij} is rating of supplier A_i (i = 1,2,...., n) with considering sub-criteria C_j (j 1,2,..., m). Then x_{ij} *is* a fuzzy number presented by a Bell-shaped linguistic number.

$$\begin{array}{c} \\ A_1 \\ A_2 \\ - \\ - \\ - \\ A_n \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & \ldots\ldots\ldots C_m \end{array} \\ \begin{pmatrix} X_{11} & X_{12} \ldots\ldots\ldots\ldots & X_{1m} \\ X_{21} & X_{22} \ldots\ldots\ldots\ldots & X_{2m} \\ - & - \ldots\ldots\ldots\ldots & - \\ - & - \ldots\ldots\ldots\ldots & - \\ - & - \ldots\ldots\ldots\ldots & - \\ X_{n1} & X_{n2} \ldots\ldots\ldots\ldots & X_{nm} \end{pmatrix} \end{array} \quad (4)$$

i.e., $x_{ij} = (aij, b_{ij} \ldots z_{11})$

Step 4: Normalization: In order to make an easy procedure all fuzzy numbers in this model are defined in close interval [0,1] so the normalized decision matrix is obtained directly. The weighted normalized fuzzy decision matrix is calculated by using equation 5.

$$V_{ij} = xij * \tilde{W}_k \quad (5)$$
$$V = [\, v_{ij} \,]_{kxm}$$

Where, V = Weighted normalized fuzzy decision matrix. $\boldsymbol{v_{ij}}$ = Normalized positive Bell-shape fuzzy numbers. k =Number of alternatives. m =Number of criteria.

Then fuzzy positive ideal solution and fuzzy negative ideal solution is determined.

Step 5: Largest and Smallest generalized mean: The results are all crisp and are defined as A* and A^-, v_j^* and v_j^- are the fuzzy numbers with the largest generalized mean and the smallest generalized mean, respectively as given in equation 6 and 7.

$$A^* = [v_1^* \ldots v_n^*] \quad (6)$$
$$A^- = [v_1^- \ldots v_n^-] \quad (7)$$

Where $\tilde{V}_j^* = \max \{ v_{ij} \}$ and
$\tilde{v}_j^- = \min \{ v_{ij1} \}$

Step 6: Distance Measurement: The distance of each supplier A_i (i =1, 2... *n)* from A* and A^- is calculated by using Vertex method as follows

$$d^*_i (v_{ij}, v_j^*) = \sum [1/11((a_{1ij} – a_{1j}^*)^2 +(a_{2ij}- a_{2j}^*)^2 +.... +(a_{11ij}-a_{11j}^*)^2)]^{0.5} \quad (8)$$

$$d^-_i (v_{ij}, v_j^-) = \sum [1/11((a_{1ij} – a_{1j}^-)^2 +(a_{2ij}- a_{2j}^-)^2 + ...+ (a_{11ij}- a_{11j}^-)^2)]^{0.5} \quad (9)$$

Where $v_{ij} = x_{ij}$ (.) $\tilde{W}_k$ and $v_{ij} = (a_{ij}, b_{ij}, c_{ij})$, $\tilde{v}_j^- = \min\{ v_{ij1} \}$,where j=1,2,3,…n, $v^-_j=(a^-_j, b^-_j , c^-_j)$, $v^*_j=(a^*_j, b^*_j , c^*_j)$ and $\tilde{v}_j^* = \max \{vij \}$ where j =1,2,3,…n

Step 7: Calculation of Closeness Coefficient: The closeness coefficient is defined to determine the ranking order of all possible suppliers or alternatives[14]. The closeness coefficient represents the distances to the fuzzy positive ideal solution and the fuzzy negative-ideal solution simultaneously by taking the relative closeness to the positive- ideal solution[15]. The Closeness Coefficient (Cci) of each alternative supplier is calculated from equation 10.

$$C_{ci} = d^*_i \;/\; d^*_i + d^-_i \quad (10)$$

Hence all the suppliers are ranked in a descending order. The larger the index value, the better the performance of the supplier and the next section deals with the implementation part.

Clustering Analysis

Referring to the framework given at Section 4.1 percentage weight for each interdependent cluster is assessed by the SSG team in order to assign linguistic variables shown in the table 4. Thus criteria in each cluster are assigned an equal weight because of the interdependency of the criteria[16]. Using Linguistic variable values the final weights of sub-criteria have been calculated from equation 2, and is shown in the table 3, table 4 and table 5.

As mentioned earlier that there are fivepotential suppliers S_1, S_2, S_3, S_4 and S_5 are considered for the research and now compared against 20 factors (sub-criteria) based on linguistic variables and fuzzy verbal variables verses five alternative suppliers, then final weightsare calculated and are shown in table 6. Then fuzzy decision matrix is computed, is shown in table 7 and is drawn from equations 4 and 5.

The next step includes finding the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) and the distances between FPIS, FNIS verses suppliers' ratings are represented using the equation 6 and equation 7, and the results are tabulated in table 8.

And hence the final step includes calculating Closeness coefficients (Cc_i) by using the Equation 5.10. The closeness coefficient of FIVE Suppliers is given in the table 9. Based on the closeness coefficients for the FIVE alternatives considered; the best among alternatives is selected. For the hypothetical sample, the closeness coefficient (Cci) for the alternative supplier 2 is higher and S_2 is being considered prioritization of Suppliers[17].
$S_2 > S_1 > S_3 > S_5 > S_4$

By adopting the TOPSIS methodology against two models it is proved to be, the closeness coefficient index is maximum for Phi-model when compared to the triangular fuzzy set theory and the same is shown in table 10 and figure 2.

Sensitive analysis

The TOPSIS method had implemented against all the three models (Phi, triangular fuzzy sets).Thereby extracting the best supplier based on the closeness coefficient values. Moreover the significance levels for each model with respect to other model are also found out by CORRELATION method which implies the phi-curve values and triangular (with clusters) values is more significant pair and the proposed method seems to be valid as shown in table 11.

Conclusion

The present paper explains the extraction of best supplier for an organization in the context of e-manufacturing. So far the attempts had made on TRIANGULAR and TRAPEZOIDAL method but this research made an attempt on Phi- FUZZY method, which reduces the vagueness to further extent.

Table-5
Clusters Weight by linguistic variables

Cluster	Criteria	Weight
C1	Web Accessibility(A) Speed(Sp) Web Hosting(W)	0.84,0.89,0.92,0.95,1,1,1,1,1 0.84,0.89,0.92,0.95,1,1,1,1,1 0.84,0.89,0.92,0.95,1,1,1,1,1
C2	Responsiveness(R) Security(Se)	0.4,0.47,0.5,0.53,0.6,0.67, 0.72,0.75, 0.84 0.4,0.47,0.5,0.53,0.6,0.67,0.72,0.75,0.84
C3	Extra Services(E) Reliability(Re) Roaming(Ro)	0,0.07,0.1,0.13,0.2,0.27,0.3,0.33,0.4 0,0.07,0.1,0.13,0.2,0.27,0.3,0.33,0.4 0,0.07,0.1,0.13,0.2,0.27,0.3,0.33,0.4
C4	Effective Marketing & Professional Education(Ex) Financial Strength(F) Management Stability(M) Technology(T)	0.17,0.22,0.25,0.28,0.33,0.39,0.42,0. 45,0.5 0.17,0.22,0.25,0.28,0.33,0.39,0.42,0.45,0.5 0.17,0.22,0.25,0.28,0.33,0.39,0.42 ,0.45,0.5 0.17,0.22,0.25,0.28,0.33,0.39,0.42,0.45,0.5
C5	Experience(E) Network Topology(N) Strategic Allowances(St) Support Resources(Su)	0.84,0.89,0.92,0.95,1,1,1,1,1 0.84,0.89,0.92,0.95,1,1,1,1,1 0.84,0.89,0.92,0.95,1,1,1,1,1 0.84,0.89,0.92,0.95,1,1,1,1,1
C6	Installation Charge(I) Monthly Charges(Mo)	0.84,0.89,0.92,0.95,1,1,1,1,1 0.5,0.55,0.58,0.61,0.67,0.72,0.75,0.7 8,0.84
C7	Legal /Beneficial Taxes	0.84,0.89,0.92,0.95,1,1,1,1,1
C8	Network Links	0.84,0.89,0.92,0.95,1,1,1,1,1

Table-6
Final weights of sub-criteria

S.I.No	Sub-Criteria	Weight
1.1	Web Accessibility(A)	625,711,756,812,900,900,900,900,900
2.1	Speed 1 mbps(S)	625,711,756,812,900,900,900,900,900
2.2	Speed 512 kbps(S1)	267,344,385,430,519,585,619,653,717
3.1	Web hosting(W)	625,711,756,812,900,900,900,900,900
4.1	Responsiveness (R)	267,344,385,430,519,585,619,653,717
5.1	Security (Se) Highly Protected	267,344,385,430,519,585,619,653,717
5.2	Security (Se1) Insecure	0,0,9,27,68,120,151,183,255
6.1	Extra Services(E)	0,0,18,51,118,185,219,252,321
7.1	Roaming (Ro)	0,0,18,51,118,185,219,252,321
8.1	Reliable (Re)	0,0,18,51,118,185,219,252,321
8.2	Un Reliable(Ur)	0,0,5,15,39,72,91,112,160
9.1	Professional Education(P)	125,177,206,237,300,349,375,400,450
9.2	Skill Of Human Resources (Hr)	75,111,131,152,200,252,281,311,375
10.1	Financial Strength(F)	125,177,206,237,300,349,375,400,450
11.1	Management Stability(M)	125,177,206,237,300,349,375,400,450
12.1	Modem Technology(Mo)	125,177,206,237,300,349,375,400,450
12,2	Rotor Technology (Ro)	53,86,105,125,173,227,258,290,358
13.1	Experience (Ex)	625,711,756,812,900,900,900,900,900
4.1	Network Topology(Nt)	625,711,756,812,900,900,900,900,900
15.1	Strategic Allowances (St)	625,711,756,812,900,900,900,900,900
16.1	Support Resources(Su)	625,711,756,812,900,900,900,900,900
17.1	Installation Charges(Ic) High	0,0,11,33,78,134,164,196,267
17.2	Installation Charges(Ic) Medium	160,215,244,276,346,422,464,507,597
17.3	Installation Charges(Ic) Low	375,444,480,522,600,649,675,699,750
18.1	Monthly Charges (Mo) High	0,0,11,33,78,134,164,196,267
18.2	Monthly Charges(Mo) Medium	160,215,244,276,346,422,464,507,597
18.3	Monthly Charges (Mo) Low	375,444,480,522,600,649,675,699,750
19.1	Legal /Beneficial Taxes	625,711,756,812,900,900,900,900,900
20.1	Network Links	625,711,756,812,900,900,900,900,900

Table-7

Suppliers rating with fuzzy linguistic variables

Sub-Criteria	ISP^1	ISP^2	ISP^3	ISP^4	ISP^5
Web Accessibility(A)	MH	H	H	MH	VH
Speed 1 mbps(S)	H	H	H	MH	H
Speed 512 kbps(S1)	MH	M	M	MH	M
Web hosting(W)	H	VH	MH	H	VH
Responsiveness (R)	VH	H	M	MH	M
Security (Se) Highly Protected	VH	VH	MH	H	VH
Security (Se1) Insecure	ML	M	L	VL	ML
Extra Services(E)	M	MH	L	VL	ML
Roaming (Ro)	VH	H	M	ML	M
Reliable (Re)	H	M	MH	M	ML
Un Reliable(Ur)	ML	M	L	VL	ML
Professional Education(P)	VH	H	H	VH	VH
Skill Of Human Resources (Hr)	MH	H	H	MH	VH
Financial Strength(F)	VH	H	VH	H	VH
Management Stability(M)	H	VH	H	VH	H
Modem Technology(Mo)	H	VH	VH	H	VH
Rotor Technology (Ro)	M	MH	ML	M	MH
Experience (Ex)	H	VH	MH	H	VH
Network Topology(Nt)	MH	M	H	M	H
Strategic Allowances (St)	H	MH	M	ML	M
Support Resources(Su)	H	VH	MH	H	M
Installation Charges(Ic) High	VL	ML	L	M	ML
Installation Charges(Ic) Medium	M	MH	ML	ML	H
Installation Charges(Ic) Low	H	VH	H	VH	VH
Monthly Charges(Mo) High	VL	ML	L	ML	ML
Monthly Charges(Mo) Medium	M	MH	M	MH	M
Monthly Charges (Mo) Low	H	VH	VH	H	VH
Legal Tax Risks(Le)	H	VH	VH	M	MH
Network Links(Ne)	VH	H	MH	MH	VH

Table-8
FPIS and FNIS

S.I. No	A^+	A^{---}
1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	9375, 9375, 9375, 9375, 9375,9375, 9375, 9375, 9375
2.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	9375, 9375, 9375, 9375, 9375,9375, 9375, 9375, 9375
2.2	17925,17925, 17925, 17925, 17925,17925, 17925, 17925, 17925	2867, 2867, 2867, 2867, 2867,2867, 2867, 2867, 2867
3.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	9375, 9375, 9375, 9375, 9375,9375, 9375, 9375, 9375
4.1	21510, 21510, 21510, 21510, 21510,21510, 21510, 21510, 21510	2867, 2867, 2867, 2867, 2867,2867, 2867, 2867, 2867
5.1	21510, 21510, 21510, 21510, 21510,21510, 21510, 21510, 21510	4016, 4016, 4016, 4016, 4016,4016, 4016, 4016, 4016
5.2	6117, 6117, 6117, 6117, 6117,6117, 6117, 6117, 6117	0,0,0,0,0,0,0,0,0
6.1	8032, 8032, 8032, 8032, 8032,8032, 8032, 8032, 8032	0,0,0,0,0,0,0,0,0
7.1	9639, 9639, 9639, 9639, 9639,9639, 9639, 9639, 9639	0,0,0,0,0,0,0,0,0
8.1	9639, 9639, 9639, 9639, 9639,9639, 9639, 9639, 9639	0,0,0,0,0,0,0,0,0
8.2	3839, 3839, 3839, 3839, 3839,3839, 3839, 3839, 3839	0,0,0,0,0,0,0,0,0
9.1	13500, 13500, 13500, 13500, 13500,13500, 13500, 13500, 13500	2987, 2987, 2987, 2987, 2987,2987, 2987, 2987, 2987
9.2	11250, 11250, 11250, 11250, 11250,11250, 11250, 11250, 11250	1125, 1125, 1125, 1125, 1125,1125, 1125, 1125, 1125
10.1	13500, 13500, 13500, 13500, 13500,13500, 13500, 13500, 13500	2987, 2987, 2987, 2987, 2987,2987, 2987, 2987, 2987
11.1	13500, 13500,13500,13500, 13500,13500, 13500,13500, 13500	2987, 2987, 2987, 2987, 2987,2987, 2987, 2987, 2987
12.1	13500,13500,13500,13500, 13500,13500, 13500,13500, 13500	2987, 2987, 2987, 2987, 2987,2987, 2987, 2987, 2987
12.2	8962, 8962, 8962, 8962, 8962,8962, 8962, 8962, 8962	267, 267, 267, 267, 267, 267, 267, 267, 267
13.1	27000, 27000,27000,27000, 27000,27000, 27000, 27000, 27000	9375, 9375, 9375, 9375, 9375,9375, 9375, 9375, 9375
14.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	6693, 6693, 6693, 6693, 6693,6693, 6693, 6693, 6693
15.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	3125, 3125, 3125, 3125, 3125,3125, 3125, 3125, 3125
16.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	6693, 6693, 6693, 6693, 6693,6693, 6693, 6693, 6693
17.1	6399, 6399, 6399, 6399, 6399,6399, 6399, 6399, 6399	0,0,00,0,0,0,0
17.2	17925, 17925, 17925, 17925, 17925, 17925, 17925, 17925, 17925	803, 803, 803, 803, 803, 803, 803, 803, 803
17.3	22500, 22500, 22500, 22500, 22500, 22500, 22500, 22500, 22500	8962, 8962, 8962, 8962, 8962, 8962, 8962, 8962, 8962
18.1	8962, 8962, 8962, 8962, 8962,8962, 8962, 8962, 8962,	0,0,00,0,0,0,0
18.2	14937, 14937, 14937, 14937, 14937,14937, 14937, 14937, 14937	1720, 1720, 1720, 1720, 1720, 1720, 1720, 1720, 1720
18.3	22500, 22500, 22500, 22500, 22500, 22500, 22500, 22500, 22500	8962, 8962, 8962, 8962, 8962, 8962, 8962, 8962, 8962
19.1	27000, 27000, 27000, 27000, 27000, 27000, 27000, 27000, 27000	6693, 6693, 6693, 6693, 6693, 6693, 6693, 6693, 6693
20.1	27000, 27000, 27000, 27000, 27000,27000, 27000, 27000, 27000	9375, 9375, 9375, 9375, 9375,9375, 9375, 9375, 9375

Table-9
Closeness Coefficient Value

Supplier	Closeness Coefficient Value
S_1	0.595089
S_2	**0.60273**
S_3	0.512298
S_4	0.488476
S_5	0.56648

Table-10
Closeness co-efficient index (*Cci*)

Supplier	CLOSENESS CO-EFFICIENT INDEX(*Cci*)	
	Phi-CURVE	TRIANGULAR
S_1	0.5950	0.5138
S_2	**0.6027**	**0.5287**
S_3	0.5122	0.4613
S_4	0.4884	0.4261
S_5	0.5664	0.4945

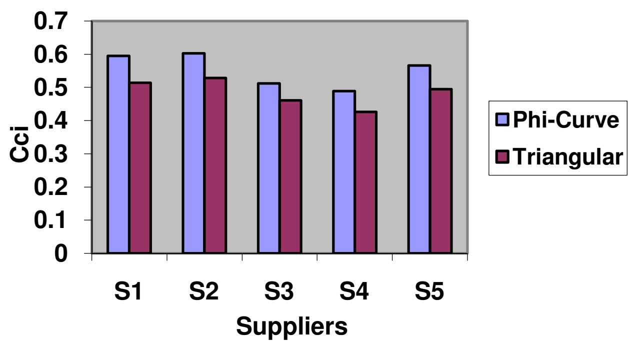

Figure-2
Graphical Representation

Table-11
Correlations Test

		Bell	Triangle
Bell	Pearson Correlation	1	.990**
	Sig. (2-tailed)		.001
	N	5	5
Triangle	Pearson Correlation	.990**	1
	Sig. (2-tailed)	.001	
	N	5	5

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