A Fuzzy Approach To Project Team Selection

Sunny Joseph Kalayathankal, John T Abraham, Joseph Varghese Kureethara

Abstract: Project team selection is a complex process in software engineering. The study uses a multiple criteria decision making (MCDM) approach for the selection of a project team under fuzzy environment. In this paper a FRI, FSS approaches are developed to the selection of project team.

Index Terms: Fuzzy set, Project team selection, Soft set

1. INTRODUCTION

A project is a temporary endeavour designed to produce a unique product, service or result with a defined beginning and end undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value [6]. The phases of Project management include initiating, planning, executing, monitoring and controlling, and closing the work of a team to achieve defined goals at the defined time.Projects are usually time constrained, and often constrained by funding and staffing. These constraints impact the quality of the deliverables. The success of project management can always be summarized with Triple Constraint - the quality of work is constrained by the project's budget, time and scope. Though the origins of triple constraints are unclear, it has been used since at least the 1950s.Most scholars consider that modern project management is started with the innovative scheduling diagram of Gantt chart by Henry Gantt in 1917. This scheduling tool created a new way of thinking for project management and gave birth to dozens of process and tools for project managers to manage the complexities of budget, quality and time. A few notable ones are critical path method (CPM), Program Evaluation Review Technique (PERT), Work Breakdown Structure (WBS), etc. The CPM identifies the longest path of critical activities to complete the project, PERT helps to analyze the task involved in completing a project, and WBS helps to decompose projects into smaller deliverables. These tools help monitoring and controlling the projects to minimize impacts of triple constraints and improve quality.In the last 30 years, as the markets become more competitive and isolated economies shifted to more global. Quality has become the de facto standard for winning a customer. Definition of quality becomes more refined to conformance to requirement. PM process received wider attention to predict and improve quality of the product. A Total Quality Management (TQM), ISO, CMMI and many more standards were born, refined and streamlined during this time to manage triple constraint and hence quality. All these standards provide fundamental management techniques, process, tools towards continuous improvements for an organization by conforming customer needs and expectations, encouraging innovation and employee participation, respecting societal values and belief, and obeying governmental regulations and statues. Though the term Triple Constraint was introduced as part of modern project management in 1950s, there are historical evidences that the early civilization these concepts were heavily used. In 2570 BC, the Pharaohs completed The Great Pyramid of Giza, the tallest man made structure for more than 3800 years, conforming to the quality requirements of Pharaoh. The project had clear time span of 20 years, budget of 100,000 workers and clear dimensions of Pyramid as the scope. Without the service of modern management concepts, tools such as cranes, bulldozers, the Egyptians managed the triple constraints and completed mammoth structures of admirable precision within time. Archaeologists suggest that Egyptians conquered the concept of WBS to employee 100,000 skilled craftsmen for the project. These employees were arranged in a highly organized tiered management structure with each side of the pyramids had a dedicated supervisor. They understood the concepts of modern Human Resources Management (HRM) very well. The importance was given for their skills, knowledge management and experience. The workers' safety and health was considered important, they lived near the construction sites, with well-equipped and furnished labour camps. Employees were paid in food and accommodation, well looked after and were allowed one day in ten to rest. Another such large project were huge manpower was used is Construction of the Great Wall of China in 208 BC. According to historical data, the labour force was organized into soldiers, common people and criminals.The modern project management techniques focus more on the aspects of monitoring and controlling of project which happens after a team has been selected. With the examples of these two ancient projects, one can observe the importance of highly skilled people in right position for the success of the project. Rightly skilled people placed at right position bring in competitive advantage to any company.Teamwork is one of the pivot factors that influence the engineering and management structure. Software fields now greatly work by forming small teams which carry out assignments relating to system management, product development, analysis, etc. This reduces the error tendencies as prominent skilled people are made part of the team. Each team comprises of people who can directly contribute to the requirements of the project.

Smith and Kalzenbach (1993) defined the concept of an optimal cross functional team required for a project. They say that it is a group of people, few from each required functional area, who are chosen carefully for complementary skills and who are mutually amenable and can work for a common goal for the project success. They will have a shared mission and approach and a fixed timeline. The members will return to their functional units or move to a different project once the project task is accomplished. Hence the project team formation is recognized to be an intricate multi-criteria problem in decision making.Topcu [13] indicated that the constraints on the cost of

- *Sunny Joseph Kalayathankal name is an Associate Professor of Department of Mathematics, K. E. College, Mannanam, Kottayam, 686561, India. E-mail: sunnyjoseph2014@yahoo.com*
- *John T Abraham is an Assistant Professor of Department of Computer Science, Bharatha Matha College, Thrikkakara, Cochin, Kerala – 682021. E-mail: author_name@mail.com*
- *Joseph Varghese Kureethara is a Professor of Department of Mathematics, CHRIST (Deemed to be University), Bangalore, Karnataka – 560029. E-mail: frjoseph@christuniversity.in*

development and establishment also lead to quality issues during the completion of the project. He also says that, evaluating the team members with respect to their skills, past performances, work quality, competency and mutual agreeability may help in resolving this issue. All of the project activities undoubtedly rely on the team structure. Thus team selection which is one of the incipient tasks of the project becomes the most relevant. Hence a strategic decision making study on the team selection procedure has now become a necessity. Though a lot of work regarding the behavioural traits of the team members that can affect the smooth functioning of the project were categorically studied, a quantitative based research in this domain is yet very limited. A fuzzified approach to this aspect was noticeably brought by Yakoob and Kawata [14], in which they made use of triangular fuzzy numbers in the selection of the candidates for work team formation.

1.1 Team and Role Structure

Success or failure of project is directly linked to the quality of the human resources selected to execute the project and the hierarchical structure adopted. In the last 50 years, Human Resources Management (HRM) has pioneered many concepts from hiring, training and development, performance review, compensation, safety and health, welfare industrial relations to termination of employees. The strategic HRM movement reinforces these concepts that any individual in a company who has responsibility for people is the HRM manager, no matter which functional division the employee reports to. The following 3 step process ensures that the employees are motivated and productive.The first step of project management is to conduct a job analysis for the project and define all the job descriptions (JD). The Job Analysis is more exhaustive than just technical skills. It shall include analyzing the entire work process, internal and external communications, work structure, etc. The JD shall include the details of jobs, remuneration, years of experience, knowledge, skill-set, expected results, behavioural and technical competencies, soft skills, etc. JD ensures to broadly cover both psychological and sociological dimensions of work and workforce.The second step is to create the hierarchical structure needed for the workforce and define the responsibility matrix. RASCI matrix is a common framework used for allocation and assignment of responsibilities to the team members in projects. The letters R, A, S, C and I in the matrix describe the level of responsibility. Letter R stands for Responsibility, A stands for Accountability, S stands for Supported, C stands for Consulted and letter I stands for Informed.The last step is to ensure a proper Job Design approach for the project by considering characteristics of the task, work flow, ergonomics, work practices, autonomy, employee abilities and availability and social & cultural expectations. Job Design ensures job satisfaction with enriched jobs. With proper job description, reporting structure and job design in place team members from the available pool can be selected.

1.2 Selecting members to Team

The team is comparable to human body, like various organs collaborate to make things happen, the varied different individuals collaborate day by day to bring success to the project. The key quality to be part of the project team is team work, which is a behavioral competency. Members bring something unique to the project team and are always gunning to make things happen [2].Team selection is no different from match making. One side of the spectrum is the requirement - clear roles and Job Descriptions. The other side is the available talents with their various capability parameters. The objective is to gain the best talents in the market that can make a difference to the project. There should be a fit between job description and the capabilities of available talent to discharge the tasks. Any mismatch is likely to result in job dissatisfaction that carries dysfunctional consequences like low productivity, increased absenteeism and attrition.There are many criteria available for comparing a talent against the job description such as Technical skill, Communication skill, Problem solving skill, behavioral competencies, Leadership Skills, Overall experience, etc. Each project may choose the right blend of criteria's that are important for that environment. These criteria help the workforce to execute project with agility and quality. In people selection process for a project, we must identify the criteria needed for each position in that project, align available human resources to business positions.Today, the normal ways of doing business has changed. Globalization and digitization has brought in level playing fields across international markets. Every business is facing VUCA threats from markets that were unknown few years back. At the same time, organizations are in a constant effort to improve productivity, performance and return on investment. The strength of the organization is strength of its team. Each organization is always on the lookout for making a dream team. MCDM ensures that the organization can build a dream team.

2 MODEL CONSTRUCTION

Nowadays, fuzzy technology is increasingly used in Project team selection studies. Project team selection is a complex process. The model presented should only be used for those cases in which there is little divergence among the DMs. This enables them to define an interval of variation for the weight of each criterion, i.e., a lower and an upper limit for the weight of each criterion. In this research paper, MCDM with dynamic weightage for each parameter is considered.In 1965, Zadeh [15] published the first paper on fuzzy set theory in the international journal of Information and Control. This theory acts as a bridge between certainty and uncertainty. So many researchers have applied this theory in real time applications. This theory is efficiently effective when the relationships are not fully understood. The fuzzy set is defined from a universal set H to [0, 1]. Normally the range of a crisp function is taken as a very large interval from -∞ to ∞. This very large range of crisp function can be mapped in to a closed interval [0, 1]. That is a very large range can be transformed into a small interval between 0 and 1 both values are inclusive. From (-∞, ∞) can be shrink to the interval [0, 1]. Then there arises a question: is this possible? This question will immediately fetch at a solution. The solution is the fuzzy set which is the most powerful set in reality. The function associated with the fuzzy set is called the membership function (MF) and the set defined by it is called fuzzy set. The membership function (MF), μ_C is defined as

$$\mu_C: H \rightarrow [0,1] \quad (1)$$

Molodtsov [5] introduced soft set (SS) which is capable of handling uncertainties. This theory has several applications in computer science, electrical engineering and Boolean algebra because it contains only two elements 0 and 1. (F, C) is called

a SS over H, where F : C→R(H), where R(H) is the set of all subsets of a universal set H and C is a collection of real valued variables.

For example, let H={O_1, O_2, O_3, O_4, O_5} the five SLCM models in software engineering. Let C={U_1, U_2, U_3, U_4} be the parameters related to this models. Suppose that F(U_1)= {O_1, O_2, O_4}, F(U_2)={O_3, O_5}, F(U_3)={O_1, O_2, O_3}, F(U_4)={O_2, O_3, O_5}.

H	U_1	U_2	U_3	U_4
O_1	1	0	1	0
O_2	1	0	1	1
O_3	0	1	1	1
O_4	1	0	0	0
O_5	0	1	0	1

Table 1: Example of Soft Set

So SS has rich potential applications in computer science and Boolean algebra. The major drawback of the soft set theory is it deals with two extremes only. To avoid these problems Maji et al. [3], [4] introduced the concept called Fuzzy Soft Set (FSS) theory which also deals with uncertainties. There is infinite number of possibilities in fuzzy soft set theory because there are infinite number of real numbers that lie between 0 and 1. The pair (F, C) is called a FSS over H, where F : C →R(H), where R(H) be the set of all fuzzy subsets of a universal set H.

Consider the previous example. Suppose that
F(U_1)={w_1/.85 , w_2/.65, w_3/.22, w_4/.89 , w_5/.25},
F(U_2)={w_1/.23 , w_2/.31, w_3/.79, w_4/.12, w_5/.87},
F(U_3)={w_1/.92 , w_2/.87, w_3/.89, w_4/.41, w_5/.27} and
F(U_4)={w_1/.34 , w_2/.95, w_3/.93, w_4/.87, w_5/.91}.

H	U_1	U_2	U_3	U_4
w_1	0.85	0.23	0.92	0.34
w_2	0.65	0.31	0.87	0.95
w_3	0.22	0.79	0.89	0.93
w_4	0.89	0.12	0.41	0.87
w_5	0.25	0.87	0.27	0.91

Table 2: Example of Fuzzy Soft Set

Nowadays, fuzzy technology is increasingly used in Project team selection studies. Project team selection is a complex process. The model presented should only be used for those cases in which there is little divergence among the DMs. This enables them to define an interval of variation for the weight of each criterion, i.e., a lower and an upper limit for the weight of each criterion. In this research paper, MCDM with dynamic weightage for each parameter is considered.

2.1 Fuzzy Rating Index Model (FRIM) for Project Team Selection

FL is a method for measuring the power of uncertainty and unsatisfaction amount of an information. One of the important issues in PM is the selection of a good project team selection. Project team selection can be solved by several methods in literature. But all these methods and techniques are not consistent and incorrect. So we can solve this problem by using fuzzy logic. Every parameter in this problem are not in crisp nature. For example, low communication skill, good problem solving skill, very good technical skill etc. are all in fuzzy nature and are called linguistic variables. The linguistic variables are not receiving any numerical values but receive some words or sentences of information. The different types of skills measure cannot be expressed as crisp values. The linguistic variables of fuzzy system for project team selection can be classified into four categories VG (very good), GD (good), FR (fair), and PR (poor). Each skill belongs to some classification. The range of the total classification belongs to [0, 1]. i. e., 0 ≤ MV ≤ 1. The lower bound is zero and the upper bound is one. There are so many methods for calculating membership values. Some authors use the formula given below to calculate triangular type membership values.

$$\mu_c(y) = \begin{cases} \frac{y-1}{m-1}, & if\ y \epsilon [l,m] \\ \frac{r-y}{r-m}, & if\ z \epsilon [m,r] \\ 0, & if\ y < l, y < r \end{cases}$$

Fuzzy numbers are also useful tools for promoting real time information systems. They are widely used in project management and project team selections in software development. If z = (z_1, z_2, z_3) and z*= (z_1^*, z_2^*, z_3^*) are any two triangular fuzzy numbers, then z+z* and zxz* are defined as:
z + z*= (z_1+ z_1* , z_2+z_2*, z_3+z_3*) and
z x z* = (z_1x z_1* , z_2xz_2*, z_3xz_3*), where z_1 ≥ 0 and z_1* ≥ 0.
In this proposed model the FRI evaluates the skill ability of each member in the project team. The selection procedure is based on the following criteria; Communication skill (CS), Technical skill (TS), Problem solving capacity (PC), Decision making skill (DM). The minimum requirements (weights) for CS is (GD), TS is (VG), PS is (GD), DM is (GD). If any of the candidates do not satisfy the minimum requirements the company flag will not assign the candidate in labour pool. The company management has decided to fix the fuzzy membership value for each category as PR ε [0, 0.25], ε [0.25, 0.5], GD ε [0.5, 0.75], VG ε [0.75, 1.0]. i. e., 0 ≤ PR ≤ 0.25, 0.25 ≤FR ≤0.5, 0.5 ≤GD ≤0.75, 0.75 ≤VG ≤1. The width of each class interval is 0.25. The upper bound of each category lies in the prefix or postfix category. The company also gives the weightage of each category as follows. Weightage of CS is 0.2, TS is 0.5, PS is 0.2, DM is 0.1 such that the sum of all weightages is 1. The membership value of a candidate is calculated using the formula:

MV = [LB + (UB - LB) * (AV /100) (2),

where LB= Lower bound, UB = Upper bound and AV = Actual value. If x_1, x_2, x_3,.... are the membership values of each categories and w_1, w_2, w_3,..... are their weights, respectively, then the fuzzy rating indices are:

(FRI)z_i=Σ[x_i*w_i], i=1 to n, (3)
(DFRI) z_i=(FRI)z_i*100. (4)

where (DFRI)z_i is the defuzzified or crisp value of (FRI)z_i of the candidate z_i. The output can be interpreted on the basis of fuzzy rating index or its defuzzified value (crisp value).

Employee z_n	(CS)	(TS)	(PS)	(DM)
z_1	VG	FR	GD	FR
z_2	GD	VG	VG	VG
z_3	VG	GD	FR	GD
z_4	FR	VG	GD	VG
z_5	FR	FR	VG	GD
z_6	VG	VG	GD	VG
z_7	VG	VG	FR	GD
z_8	GD	FR	GD	VG
z_9	VG	VG	FR	FR
z_{10}	GD	FR	GD	GD

Table 3: Fuzzy classification of the candidates in a labour pool

Employee z_n	(CS)	(TS)	(PS)	(DM)
z_1	70	75	80	85
z_2	90	80	75	80
z_3	80	68	83	86
z_4	89	90	94	96
z_5	92	96	84	90
z_6	97	95	91	96
z_7	92	95	87	94
z_8	81	100	86	75
z_9	85	72	78	89
z_{10}	95	97	100	99

Table 4: Crisp percentage of the candidates in a labour pool

Employee z_n	CS	TS	PS	DM
z_1	0.925	0.4375	0.7	0.4625
z_2	0.725	0.95	0.9375	0.95
z_3	0.95	0.67	0.4575	0.715
z_4	0.4725	0.975	0.735	0.99
z_5	0.48	0.49	0.96	0.725
z_6	0.9925	0.9875	0.7275	0.99
z_7	0.98	0.9875	0.4675	0.735
z_8	0.7025	0.5	0.715	0.9375
z_9	0.9625	0.93	0.445	0.4725
z_{10}	0.7375	0.4925	0.75	0.7475

Table 5: Fuzzyfication of Crisp value of the candidates in a labour pool

The company wants to select 4 people from 10 candidates. The Company decided that the cut of rate of the defuzzified value of fuzzy rating index is 75 percentage. The flag 1 is selected and 0 is not selected. The Candidates selected from the labour pool are z_2, z_4, z_6 and z_7, and z_6 got the first position.

2.2 FSS Model for Project Team Selection

We now develop a simple and effective model for project team selection, which is the combination of fuzzy and soft set theory. The E - Bank is defined as a square table or square matrix. Both are labelled by variables.Entries w_{ij} = the number of attributes for which $w_i \geq w_j$. It is a positive number and satisfying the condition $w_{ij} \geq 0$ and for i = j, w_{ij}=n. i. e. , $0 \leq w_{ij} \leq n$, where n = number of attributes. The corresponding square matrix is called E - Bank and its order is always n. The three important definitions for this model construction are defined below:

Model factor, $E_{ri} = \Sigma w_{ij}$, j= 1 to n.

The Param factor, $Par_j = \Sigma w_{ij}$, i=1 to n.

The Efficiency indicator = EI= $E_{ri} - Par_j$

2.3 Optimization Algorithm

We now develop a simple and effective optimization algorithm.

1. Selection of candidates in the labour pool (O_i).
2. Identifying the parameters (U_j).
3. Compute the fuzzy soft set.
4. Compute the E-Bank.
5. Calculation of E_{ri} and Par_j
6. Estimation of Efficiency indicator.
7. Construction of E_{ri} and Par_j optimization table.
8. Identification of project team selection from the optimization table.

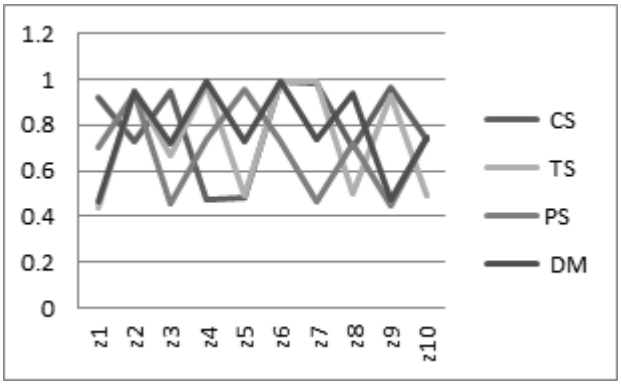

Fig. 2. Fuzzyfication of Crisp value of the candidates in a labour pool

Employees z_n	$(FRI)_{zi} = \Sigma[x_i * w_i]$, i=1 to n.
z_1	0.925 * 0.2 + 0.4375 * 0.5 + 0.7 * 0.20 + 0.4625 * 0.1
z_2	0.725* 0.2 + 0.95*0.5 + 0.9375*0.20 + 0.95* 0.1
z_3	0.95 * 0.2+ 0.67* 0.5 + 0.4575*0.20+ 0.715* 0.1
z_4	0.4725 * 0.2+ 0.975*0.5+ 0.735* 0.20+ 0.99* 0.1
z_5	0.48 * 0.2 + 0.49 * 0.5 + 0.96 * 0.20 + 0.725* 0.1
z_6	0.9925 *0.2 + 0.9875 * 0.5 + 0.7275 * 0.20 + 0.99 * 0.1
z_7	0.98 * 0.2 + 0.9875*0.5 + 0.4675*0.20+ 0.735*0.1
z_8	0.7025*0.2+ 0.5*0.5+ 0.715*0.20 + 0.9375*0.1
z_9	0.9625*0.2 + 0.93*0.5+ 0.445*0.2 + 0.4725*0.1
z_{10}	0.7375*0.2 + 0.4925*0.5+ 0.75*0.2 + 0.7475*0.1

Table 6: Computation of Fuzzy Rating Index (FRI)

Employee z_n	$(FRI)_{zi}$	(DFRI)zi	Rank	Flag (1 or 0)
z_1	0.59	59	10	0
z_2	0.9025	90.25	2	1
z_3	0.688	68.8	6	0
z_4	0.828	82.8	4	1
z_5	0.6055	60.55	9	0
z_6	0.9365	93.65	1	1
z_7	0.85675	85.675	3	1
z_8	0.62725	62.725	7	0
z_9	0.79375	79.375	5	0
z_{10}	0.6185	61.85	8	0

Table 7: Computation of DFRI & Crisp Output

Employee z_n	(CS * 0.2)	(TS* 0.5)	(PS* 0.2)	(DM * 0.1)
z_1	0.185	0.21875	0.14	0.04625
z_2	0.145	0.475	0.1875	0.095
z_3	0.19	0.335	0.0915	0.0715
z_4	0.0945	0.4875	0.147	0.099
z_5	0.096	0.245	0.192	0.0725
z_6	0.1985	0.49375	0.1455	0.099
z_7	0.196	0.49375	0.0935	0.0735
z_8	0.1405	0.25	0.143	0.09375
z_9	0.1925	0.465	0.089	0.04725
z_{10}	0.1475	0.24625	0.15	0.07475

Table 8: FSS with multiplying weightage of candidates in a labour pool

Employees z_n	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8	z_9	z_{10}
z_1	4	1	1	1	1	0	1	1	1	1
z_2	3	4	3	2	3	1	2	4	3	3
z_3	3	1	4	1	2	0	0	2	2	2

z_4	3	2	3	4	2	3	2	3	3	2
z_5	3	1	2	2	4	1	1	1	2	1
z_6	4	3	4	3	3	4	4	4	4	3
z_7	3	2	4	2	3	1	4	2	4	2
z_8	3	0	2	1	3	0	2	4	2	2
z_9	3	1	2	1	2	0	0	2	4	2
z_{10}	3	1	2	2	3	1	2	2	2	4

Table 9: E-Bank

Employees z_n	AF	PF	EI	R	Flag 1 or 0
z_1	12	32	-20	9	0
z_2	28	16	12	2	1
z_3	17	27	-10	8	0
z_4	26	19	7	4	1
z_5	18	26	-8	7	0
z_6	36	10	26	1	1
z_7	27	18	9	3	1
z_8	19	25	-6	6	0
z_9	17	27	-10	8	0
z_{10}	22	22	0	5	0

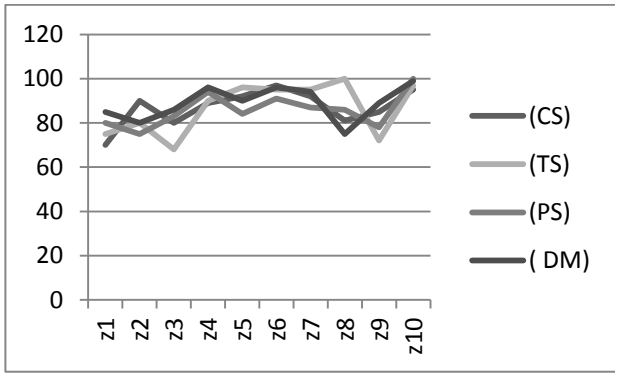

***Fig.1**. Crisp percentage of the candidates in a labour pool*

Table 10: Ranking (R) table for Project Team Selection

The Candidates selected from the labour pool are z_2 , z_4, z_6 and z_7.

4 CONCLUSION

In this paper, a FRI, FSS approaches are considered to the selection of project team. The candidates selected from the labour pool are z_2, z_4, z_6 and z_7, i. e., $z_6 > z_2 > z_7 > z_4$.

REFERENCES

[1] K. Atanassov, Intuitionistic Fuzzy sets, \emph {Fuzzy sets and Systems} 20 (1986) 87-96.

[2] Adil Baykasoglu , Turkay Dereli , Sena Das , Project Team Selection Using Fuzzy Optimization Approach, Cybernetics and Systems: An International Journal, 38: 155–185

[3] P.K. Maji, R. Biswas, A.R. Roy, Fuzzy Soft sets, The Journal of Fuzzy Mathematics 9(3) (2001) 589 - 602.

[4] P. K. Maji, R. Biswas, A. R. Roy, Intuitionistic Fuzzy Soft Sets, The Journal of Fuzzy Mathematics 9(3) (2001) 677-692.

[5] D. Molodtsov, Soft Set Theory - First Results, Computers and Mathematics with Applications 37 (1999) 19 - 31.

[6] Nokes, Sebastian, The Definitive Guide to Project Management, 2nd Edn. London (Financial Times / Prentice Hall): (2007). ISBN 978-0-273-71097-4.

[7] S. J. Kalayathankal, G. S. Singh, P. B. Vinodkumar, Ordered Intuitionistic Fuzzy Soft Sets, Journal of fuzzy mathematics 18(4) (2010) 991-998.

[8] S.J. Kalayathankal, G. Suresh Singh, P.B. Vinodkumar, Sabu Joseph, Jobin Thomas, Ordered intuitionistic fuzzy soft model of flood alarm, Iranian Journal of Fuzzy Systems 8(1) (2011) 29-39.

[9] S. J Kalayathankal, John T Abraham, A Fuzzy Decision Making Approach to SLCM Selection, International Journal of Civil Engineering and Technology 8(6) (2017) 178-185.

[10] Kalayathankal S. J, Abraham, J. T, A Fuzzy Soft Software Lifecycle Model, International Journal of Civil Engineering and Technology 8(8) (2017) 755-761.

[11] Kalayathankal S. J, Abraham J. T, Kureethara J. V, A Modified Fuzzy Similarity Measure Decision Making Approach to SLCM Selection, International Journal of Computer Sciences and Engineering 5(9) (2017) 32-39.

[12] \bibitem{sun9}S. J. Kalayathankal, G.S. Singh, P. B. Vinodkumar, Ordered Intuitionistic Fuzzy Soft Sets, Journal of fuzzy mathematics 18(4) (2010) 991 - 998.

[13] Topcu Y, A decision model proposal for construction contractor selection in Turkey, Building and Environment, 39(4) (2004) 469-481.

[14] Yaakob S. B, S. Kawata, Workers' placement in an industrial environment, Fuzzy Sets and Systems, 106 (1999) 289–297.

[15] L. A. Zadeh, Fuzzy Sets, Information and Control 8 (1965) 338 - 353.

[16] Chen S.M, A new approach to handling fuzzy decision making problems, \emph{IEEE Transactions on Systems, Man, and Cybernetics} 18 (1988) 1012-1016.

[17] L.I. Dengfeng, Chuntian Cheng, New similarity measures of intuitionistic fuzzy sets and application to pattern recognitions, \emph {Pattern Recognition Lett.} 23 (1–3) (2002) 221-225.

[18] S. J. Kalayathankal, G.Suresh Singh and P.B.Vinodkumar, Some similarity measures of ordered intuitionistic fuzzy sets, \emph {Global Journal of Mathematical Sciences: Theory and Practical}, Accepted (May 2009).

[19] S. J. Kalayathankal, G. Suresh Singh, MADM models using ordered ideal intuitionistic fuzzy sets, \emph {Advances in fuzzy mathematics}, Accepted (November 2009).

[20] Zeshui Xu, Some similarity measures of intuitionistic fuzzy sets and their applications to multiple attribute decision making, \emph {Fuzzy Optim.Decis.Making} 6 (2007) pp. 109-121.