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MODIFIED FUZZY PROMETHEE APPROACH FOR AGILE METHOD SELECTION USING FUZZY AHP

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Abstract: Agile methods have came up as an alternative to traditional software development by providing faster and lean ways to avoid overheads which are being imposed intrinsically by traditional methods. With their widespread use many organizations are practically and technically able to adapt on agile approach effectively and rapidly. There are number of approaches to help in such a transition. However, it becomes a mammoth task for project analyst to decide upon which agile method should be used for a particular project, in the absence of any well defined guidelines or framework. As there is lack of any empirical approach for agile method selection thus this paper provides a roadmap based upon modified Fuzzy PROMETHEE with the help of Fuzzy Analytic Hierarchy Process (AHP). This paper provides a framework to choose among widely used and popular agile development methods like Extreme Programming (XP), Lean development, Scrum, Dynamic Software Development Method (DSDM), Feature-driven Development (FDD) and Crystal Clear. Because of lack of any scientific and empirical work in this field, these world widely used and tested methods would provide the authenticity and acceptability of this approach, which is sometimes questioned in agile development method selection. This work would definitely prove to be an important contribution in this field for further improvement and research

Key Words: ***Fuzzy AHP, Agile Development Methods, Fuzzy PROMETHEE, Scrum, XP, FDD, Crystal Clear, DSDM.***

1. INTRODUCTION

1.1 Agile Development

The Agile Manifesto explicitly states that priority should be given to ‘‘individuals and interaction over processes and tools, customer collaboration over contract negotiation, working software over comprehensive documentation, and responding to changes over following a plan’’ [1]. Thus these agile principles promotes the flexibility by allowing changes to project requirements and scope. In nutshell, an abstract high level project scope is defined initially and after each iteration it is revised. Herein, the requirements are initially discussed with the customer and are documented as a customer requirement list; every few weeks they are again analyzed,

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discussed and thus better understood, to redefine the scope of the next iteration. The customer and the development team works very closely to meet such definitions and to validate the product constantly. As the development process is dynamic thus it is open to changes at any given moment in areas that are identified.

Many agile development methods have been existing since 1980's [24] and the evolution process is still ongoing. Agile methods are a subset of evolutionary and iterative methods and are based on opportunistic development and iterative enhancement. In view of the broad range of different agile development methods, we have chosen those methods which are currently being used world widely by different organizations. These methods are Scrum, Extreme Programming (XP), Crystal Clear, Dynamic Software Development Method (DSDM), Feature-driven Development (FDD) and Lean development. A common point for these all agile methods is the implementation of software development as an empirical process. Apart from commonality these methods also differ in their processes and practices [27], the detailed explanation of these agile methods is out of the scope of this paper [25]. Still there are few intrinsic parameters which are further discussed in the proposed approach that can be used to differentiate among these methods.

1.2 Multi-Criteria Decision Making

The process of decision making is evolving and improving day by day, which eventually leads to the new methods which provide an addition to the strong base of this methodology of making decisions. Basically the decision making problem consists of choosing the best or optimal solution among several alternatives. The selection of the optimal solution depends not only on the criteria itself but it is also affected by the individual preferences of the individual decision maker. Many methods have been come across in order to simplify and standardized this process of making decision. The Fuzzy Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is the most famous and world widely accepted method of multiple criteria decision making problems. It was coined by Brans et al. [30] and among several available outranking methods, it is most widely used. Similar to other outranking methods, the Fuzzy PROMETHEE also examines the pair wise comparison of all alternatives with respect to every criteria which measures the dominance of one alternative over the another using fuzzy logic instead of binary relations. The Analytic hierarchy Process (AHP) was proposed by Saaty [21] in 1980. During decision making process, on one hand we have several parameters in our mind and on the other hand we have different alternatives among those we have to select the optimal or preferably best one. In fuzzy AHP the linguistic variables are used instead of membership scales of 1-9 thus it therefore handles with the incapability of AHP to deal with the subjectiveness of individual preferences in the pair wise comparison process.

2. PROPOSED FRAMEWORK

2.1 Roadmap for Agile Development Method Selection

In this section we have proposed a roadmap for deciding the best agile development method among several using an empirical approach. As the scientific work is scarce in this field and there are no well defined metrics or indicators defined thus it becomes a very difficult and unmanageable task for the project analyst to select the best appropriate agile method among so many available methods according to the requirement stated by the customer. The main goal of this section is to propose a roadmap for systematically undertaking this task, keeping into consideration each and every related aspect with the help of modified Fuzzy PROMETHEE which uses Fuzzy Analytic Hierarchy process. Instead of crisp value, a linguistic value has to be selected from Table 1. The value selected will indicate the importance or dominance of each factor asked in the criteria.

Table 1: Linguistic Scale for Fuzzy Conversion

Linguistic Variable	Saaty's Scale	Triangular Fuzzy Scale
Equal Importance (EI)	1	(1,1,1)
Moderate Importance (MI)	3	(1,3,5)
Strong Importance (SI)	5	(3,5,7)
Very Strong Importance (VSI)	7	(5,7,9)
Extremely Strong Importance (ESI)	9	(7,9,9)

2.2 Procedure for Selection

In order to choose the most appropriate agile development method among several alternatives, the modified Fuzzy PROMETHEE is used, which consists of the various steps described below. The flow of process control for agile development method selection explains how the fuzzy analytic hierarchy process can be used for the calculation of the weights of different criteria. The identification and formulation of criteria and then the development of problem hierarchy are also explained in detail. The Fuzzy AHP method is shown in detail with calculations using tables and the various steps in Fuzzy PROMETHEE are also explained with calculations. The different steps of the proposed approach using modified Fuzzy PROMETHEE method are the following:

- Identify Criteria and Alternatives
- Design Problem hierarchy
- Fuzzy AHP is used to calculate the weights of relative importance of the criteria
- Preference function is decided
- Multiple criteria preference index is calculated
- Entering flow φ-(a), Leaving flow φ+(a) and Net flow φ(a) are calculated
- Based on the score ranking is given to each alternative
- Selection of optimal solution in the form of Appropriate Agile Development Method

Step-1: Every agile method is consists of processes, which are strongly supported by principles and values. In this step we have identified and defined four criteria and these criteria have been identified by surveying different agile methods, the agile manifesto and principles. These criteria are finalized on the basis of the review of available literature in this field. The four criteria identified are the following:

- Rigidity/Reluctance to Change
- Documentation and Formalization

- Process Overhead
- Reliability and Scalability

The above identified criteria does not guarantee the all possible criteria required, thus some criteria can be added or removed from the list if required according to the project requirement. After this, the problem hierarchy model is designed for the Selection of agile development method as shown in Fig. 1:

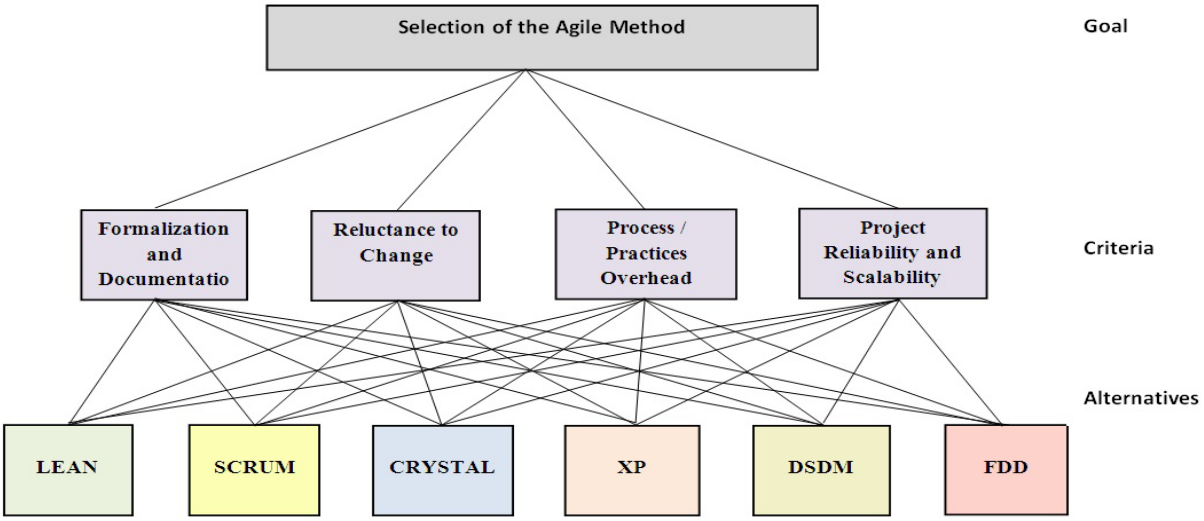

Figure 1: Problem Hierarchy for Selection of Agile Development Method

Step-2: The next step is to calculate the weights of the four criteria using the fuzzy analytic hierarchy process method. The following steps are:

• Defining Problem hierarchy

• Fuzzy comparison matrix

• Normalization of weight vector

• Calculation of local priorities

• Calculation of global priorities

The problem hierarchy is defined as shown in Fig. 1. Then the fuzzy comparison matrix is computed based upon the available literature and inputs received from industry experts. The matrix is shown in Table 2.

Table 2: Fuzzy Comparison Matrix

	Level of Formalization	Rigidity to Change	Process Cost	Reliability and Project Complexity
Level of Formalization	(1,1,1)	(0.2,0.33, 1)	(1,1,1)	(1,1,1)
Rigidity to Change	(1,3,5)	(1,1,1)	(1,3,5)	(1,3,5)
Process Cost	(1,1,1)	(0.2,0.33, 1)	(1,1,1)	(1,3,5)
Reliability and	(1,1,1)	(0.2,0.33,	(0.2,0.33	(1,1,1)

Project Complexity		1)	,1)	

If the value of Consistency Ratio is under 10%, the results can be accepted [12]; otherwise there is need to revise the subjective judgment. As in our case the Consistency Ratio comes out to be 2 % thus approximation is quite good. Using this matrix and equation (1), the respective weights are calculated as shown in Table 3.

$$w_k^S = \frac{\left(\prod_{j=1}^{n} a_{kj}^S\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}^M\right)^{1/n}} \quad (1)$$

Table 3: Weights of Criteria

Criteria	Weights
Formalization and Documentation	0.225
Reluctance to Change	0.323
Process/Practices Overhead	0.214
Project Reliability and Scalability	0.238

Step-3: In next step the information about the preference function is gathered after calculating weights of the criteria using fuzzy AHP method. In our case we have used the fuzzy preference function using “usual function”. This function defines the preference degree in the linguistic range, among two alternatives with respect to every criterion. The pair wise comparison of Reluctance/Rigidity to Change, Formalization and Documentation, Project Reliability and Scalability and Process Overhead in Table IV.

Table 4: Preference values from the pair wise comparisons of the alternatives with respect to each criteria

Formalization and Documentation

	LEAN	SCRUM	CRYST	XP	DSDM	FDD
LEA		(1,1,1)	(0.2,0.3	(0.14,0.	(0.2,0.1	(0.11,0.
SCR	(1,1,1)		(1,1,1)	(0.2,0.3	(0.14,0.	(0.2,0.1
CR	(1,3,5)	(1,1,1)		(1,1,1)	(0.2,0.3	(0.14,0.
XP	(3,5,7)	(1,3,5)	(1,1,1)		(1,1,1)	(0.2,0.3
DS	(5,7,9)	(3,5,7)	(1,3,5)	(1,1,1)		(1,1,1)
FD	(7,9,9)	(5,7,9)	(3,5,7)	(1,3,5)	(1,1,1)	

Reluctance/Rigidity to Change

	LEAN	SCRUM	CRYST	XP	DSDM	FDD
LEAN		(3,5,7)	(1,3,5)	(5,7,9)	(0.14,0.	(0.2,0.1
SCRU	(0.14,0		(1,1,1)	(1,1,1)	(0.2,0.1	(0.11,0.
CRYS	(0.2,0.	(1,1,1)		(0.2,0.3	(0.2,0.1	(0.11,0.
XP	(5,7,9)	(1,1,1)	(1,3,5)		(0.2,0.1	(0.11,0.
DSD	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)		(0.2,0.3
FDD	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(1,3,5)	

Process Overhead

	LEAN	SCRUM	CRYST	XP	DSDM	FDD
LEAN		(1,3,5)	(0.11,0.	(5,7,9)	(0.14,0.	(0.2,0.1
SCRU	(0.2,0.		(1,1,1)	(0.2,0.3	(0.2,0.1	(0.11,0.
CRYS	(7,9,9)	(1,1,1)		(1,1,1)	(0.2,0.1	(0.11,0.
XP	(0.2,0.	(1,3,5)	(1,1,1)		(0.2,0.1	(0.11,0.
DSD	(3,5,7)	(5,7,9)	(5,7,9)	(5,7,9)		(1,1,1)
FDD	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(1,1,1)	

Reliability and Scalability

	LEAN	SCRUM	CRYST	XP	DSDM	FDD
LEAN		(0.2,0.3	(0.2,0.1	(0.14,0.	(5,7,9)	(7,9,9)
SCRU	(1,3,5)		(0.2,0.3	(1,1,1)	(5,7,9)	(7,9,9)
CRYS	(5,7,9)	(1,3,5)		(1,1,1)	(7,9,9)	(7,9,9)
XP	(3,5,7)	(1,1,1)	(1,1,1)		(7,9,9)	(7,9,9)
DSD	(0.2,0.	(0.2,0.1	(0.11,0.	(0.11,0.		(1,1,1)
FDD	(0.11,0	(0.11,0.	(0.11,0.	(0.11,0.	(1,1,1)	

The last step is to calculate the preference indices which include entering flow, leaving flow and net flow as shown in Table V. The entering, leaving and net flows of the respective alternatives are calculated based upon Equations (1), (2), and (3). From the results it has been found that Scrum comes out to be the best alternative among all according to the present scenario. The preference indices are also represented in the form of graph as shown in figure 3.

$$\emptyset^{+}(a\boldsymbol{i}) = \sum_{j=1, j\neq i}^{n} \prod(\mathrm{a}\boldsymbol{i}, \mathrm{a}\boldsymbol{j}) \quad (1)$$

$$\emptyset^{-}(a\boldsymbol{i}) = \sum_{j=1, j\neq i}^{n} \prod(\mathrm{a}\boldsymbol{i}, \mathrm{a}\boldsymbol{j}) \quad (2)$$

$$\emptyset^{net}(a\boldsymbol{i}) = \emptyset^{+}(a\boldsymbol{i}) - \emptyset^{-}(a\boldsymbol{i}) \quad (3)$$

Table 5: Resulting preference indices with leaving, entering, and net flows

	LEAN	SCRUM	CRYSTAL	XP	DSDM	FDD	Ø+	NET Flow	Ranking
LEAN		2.60338	1.14513	3.86549	1.82326	2.08295	11.52021	8.44301	2
SCRUM	1.12243		0.88338	0.78489	1.7983	2.07359	6.66259	10.27515	1
CRYSTAL	4.28193	1.476		0.84173	2.1707	2.09159	10.86195	2.88578	3
XP	4.6081	1.878	1.646		2.28095	2.15459	12.56764	2.09769	4
DSDM	4.2957	4.9197	4.46256	4.01256		0.84173	18.53225	-8.81304	5
FDD	5.65506	6.06066	5.61066	5.16066	1.646		24.13304	-14.8886	6

Ø-	19. 96322	16. 93774	13.7 4773	14. 66533	9. 71921	9. 24445

In the final step, sorting is used for the final ranking. As illustrated in Fig. 3, that the order of the ranking of different alternatives turns out to be Scrum > Lean > Crystal> XP > DSDM > FDD. Thus in the present scenario Scrum has come out to be the best choice.

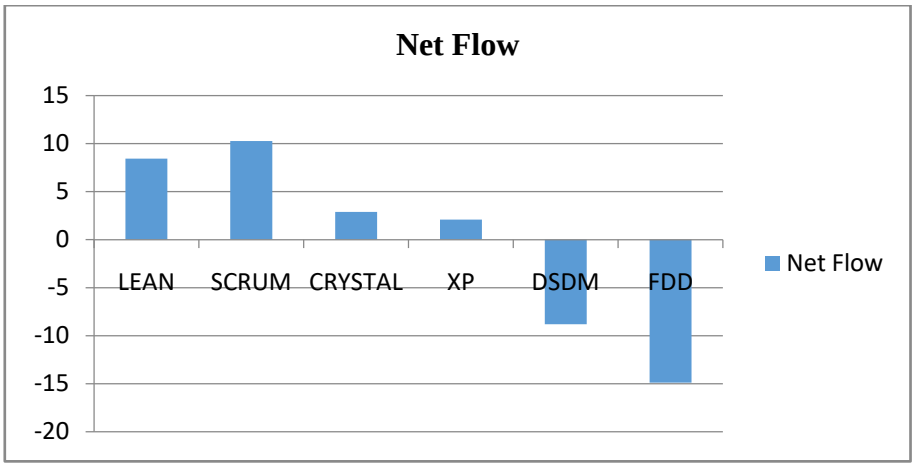

Figure 3. Comparative Representation of Flows

3. CONCLUSION

This paper has provided an empirical framework to select among different agile development methods, the most appropriate agile method best suited for a specific project. As there is a lack of any scientific work in this field and there are no metrics defined for agile development thus we have relied upon globally accepted and tested methods like AHP and PROMETHEE, so as to produce more authentic and reliable results. As there is lot of subjectiveness because of decision makers preferences thus in future scope it would be better to use fuzzy logic to deal with the inability in the pair wise comparison. Further Artificial Neural Network can also be used to train the network and producing correct results even for inconsistent input. By taking such a systematic approach for selection and development, this framework inherently addresses the major concern of security in projects using agile approach. We hope that this work would prove to be a pivotal point in this field for further research and improvement.

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