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A MULTILEVEL HYBRID APPROACH FOR SELECTION OF AGILE DEVELOPMENT METHOD USING AHP, PROMETHEE AND FUZZY LOGIC

VIŠEKRITERIJUMSKI HIBRIDNI PRISTUP U IZBORU METODE AGILNOG RAZVOJA PRIMENOM AHP, PROMETHEE I FAZI LOGIKE

Originalni naučni rad / Original scientific paper
UDK /UDC: 519.816
Rad primljen / Paper received: 1.03.2017

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Keywords
- agile development methods
- agility indicator
- AHP and Fuzzy AHP
- PROMETHEE and Fuzzy PROMETHEE
- Crystal Clear
- Scrum
- DSDM, XP, FDD

Ključne reči
- metode agilnog razvoja
- indikator agilnog razvoja
- AHP i Fazi AHP
- PROMETHEE i Fazi PROMETHEE
- Crystal Clear
- Scrum
- DSDM, XP, FDD

Abstract

Today's software industry is striving for rapid software delivery with keeping in view the changing customer requirements. Agile development approach has evolved in order to fulfil the needs of dynamic environment in which traditional approaches were failing to cope with. It has the cutting edge like fast release and minimum documentation which results in maximizing speed and profit. However, the most difficult task is to make the decision such that the agile development method should be chosen according to the given requirements of the particular project. In the absence of any empirical work, we have proposed a multilevel hybrid approach using the world widely accepted methods as Analytic Hierarchy Process (AHP), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) and Fuzzy logic. We have calculated results from four different methods of multi criteria decision making and the final result is evaluated using the rank aggregation methods. This work would prove to be a pivotal point in the field of agile development as it includes these empirical methods which provide the much awaited authenticity and reliability, which sometimes is questioned in case of agile approach.

Izvod

Današnja industrija softvera stremi ka brzom kreiranju softvera, imajući u vidu promenljive zahteve poslodavca. Pristup agilnog razvoja se pojavio kako bi ispunio očekivanja dinamičkog okruženja u kojem tradicionalni pristupi nisu bili uspešni. Prednost je u brzom izvođenju i minimalnoj dokumentaciji, čime se postižu efikasnost i profit. Međutim, najteži deo posla je u donošenju takvih odluka, kojima odgovara metoda agilnog razvoja prema postojećim zahtevima specifičnog projekta. U odsustvu empirijskog istraživanja, predlažemo višekriterijumski hibridni pristup korišćenjem metoda široko prihvaćenih u svetu, kao što su: Analitički hijerarhijski proces (AHP); PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation); i Fazi logika. Proračunom smo dobili rešenja četiri različite metode za višekriterijumsko odlučivanje, a konačni rezultat je dobijen primenom agregacionih metoda rangiranja. Ovaj rad se pokazuje kao krucijalna tačka u polju ubrzanog razvoja, jer u sebi sadrži ove empirijske metode koje obezbeđuju već dugo očekivanu autentičnost i pouzdanost, što se ponekad dovodi u pitanje u slučajevima agilnog pristupa.

INTRODUCTION

The Agile development methods are a subset of evolutionary and iterative methods and they are based on opportunistic development and iterative enhancement processes. The Agile Manifesto clearly prioritize 'individuals and the interactions among them over the tools and processes used, customer collaboration and intensive involvement over the contract negotiation, working software in the form of periodic deliverables over comprehensive documentation, and responding to changes according to the customer requirements over following a pre-determined plan', /1/. These agile principles intrinsically encourage the flexibility which allows the changes to the customer requirements as well as to the scope of the project. Thus, this dynamic development process allows the openness to changes in any identified areas at any given time.

Since the 1980's, a number of agile methods have evolved /2/ and the process of evolution has not ceased to date. Thus, from this long list of agile methods, we have selected those methods which are being widely used all over the world with reasonable amount of acceptability. These agile development methods are Crystal Clear /6/, Extreme Programming (XP) /4, 5/, Scrum /3/, Dynamic Software Development Method (DSDM) /8/, Lean development /7/, and Feature-driven Development (FDD), /9/. A common thing among these agile methods is that the implementation of software development is an empirical process in all these methods. Being from the same family of iterative and incremental approach, there are so many common things among these methods but still they do differ when it comes to their practices, processes and basic principles /10/, the further insight into these agile development methods is out of the scope of this paper, /16/. Based upon the differences in their processes and practices, we have taken few parameters into our consideration which are discussed later in the paper.

Multi-criteria decision making

Multi criteria decision making involves explicitly evaluating multiple conflicting criteria in the process of decision making. To make better decisions it is always good to structure complex problems well and taking into consideration the multiple criteria explicitly. There have been number of advances in this field of the multiple-criteria decision-making discipline since early 1960s. The decision making process is improving day after day, as the new methods are evolving and providing the substantial base for making them more and more reliable. The problem of decision making is all about selecting the best possible optimal solution among several conflicting alternatives. This process of finding the optimal solution not only depends merely upon the criteria itself but also influenced by the preferences of the decision maker. The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is one of the most reliable and famous method of multiple criteria decision making problems. It came into existence by Brans et al. /21/, and is used widely among several other available outranking methods. The Analytic hierarchy process (AHP) was coined by Saaty /12/ in 1980. The decision making process involves several conflicting criteria in one hand to choose among different alternatives available on the other hand. In fuzzy logic the linguistic variables are considered instead of crisp membership scales of 1-9, by doing this we can therefore handle the subjectiveness which is there because of individual preferences.

PROPOSED ROADMAP

It is always a Hercules task for a project analyst to select the most appropriate agile method for a given project among several available agile methods, in the absence of any empirical approach, /11/. This section purposes a multilevel hybrid approach which will take into consideration most of the project related aspects, and uses the most widely used and accepted methods as AHP, PROMETHEE and Fuzzy logic, as shown in Fig. 1.

Selection process for the most appropriate agile development method

In this section, firstly the AHP is used to rank the agile methods and then to compensate the subjective behaviour of the decision maker. Fuzzy AHP is used to rank the same methods. Thereafter, PROMETHEE and Fuzzy PROMETHEE are used to rank the agile methods. At third level, rank aggregation methods are used to aggregate the ranks produced from these four methods and thus, at the last level the most appropriate agile method is selected according to the requirements of the given project.

AHP. The Analytic hierarchy process (AHP) eigen vector is used for objective evaluation which also takes care of the subjective nature of the human judgment. The eigen value is further used for the verification of the evaluation consistency. As decision making involves different criteria according to a given problem, thus, we have used agile manifesto and agile principles for selecting the criteria. The criteria chosen take care of every aspect of the project, like project analyst, team, customer, etc. The value given to each criterion is a crisp value between 1 to 10, where 1 is used for least importance, and 10 indicates the highest importance. After deep analysis and study, the major four criteria which are perfectly in tune with the agile values, also mentioned in the Agile Manifesto /1/ criteria, are:

- Rigidity to change
- Level of formalization
- Process cost
- Project complexity and reliability.

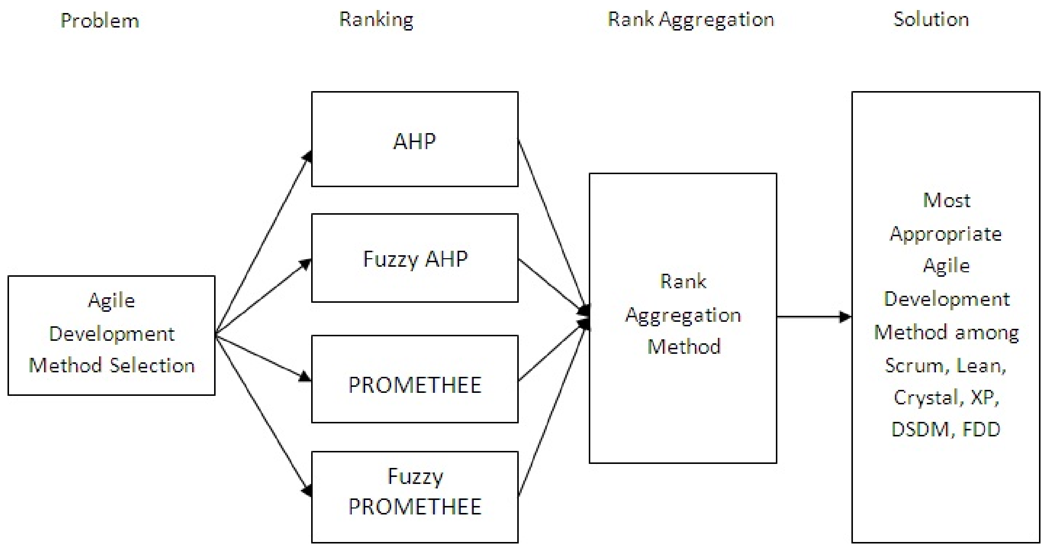

Figure 1. Process flow of agile development method selection.

Table 1. Consolidated comparison matrix.

	Level of formalization	Rigidity to change	Process cost	Project complexity and reliability
Level of formalization	1	0.7	1	1
Rigidity to change	1.43	1	1.43	1.43
Process cost	1	0.7	1	0.8
Project complexity and reliability	1	0.7	1.25	1

Each project differs from others in some respect, thus, every project has different requirements accordingly. Therefore, project analyst can make an addition to this list of criteria and can also remove some criteria according to the need of the project. For calculating ranks and weights, a crisp comparison matrix is filled from five industry experts, and a consolidated matrix is computed with the help of a weighted geometric mean of these participants, as shown in Table 1.

The Consistency Ratio is calculated based upon this comparison matrix and if it is under 10% then the judgment is accepted, /12/, otherwise we have to modify the preferences. In our case, the consistency ratio has come out to be 0.2%, which is quite a good approximation /20/. The ranks and weights are calculated as shown in Table 2, and as the selection criteria are conflicting in nature, thus, the values are normalized which are thus used to calculate the value of Agility Indicator is as shown in Table 3. The higher value of agility indicator reflects higher preference for a particular agile method and vice-versa. Thus, the ranking order in this case has come to be CRYSTAL > XP > SCRUM > LEAN > DSDM > FDD.

Table 2. Weights and ranks of criteria.

Criteria	Weights	Rank
Level of formalization	17.55%	3
Rigidity to change	47.90%	1
Process cost	22.86%	2
Reliability and project complexity	14.62%	4

Fuzzy AHP. In case of Fuzzy AHP, a linguistic value has to be selected as shown in Table 4. The value selected reflects the measure of importance of each criterion.

The fuzzy comparison matrix is created as shown in Table 5. Although values can also be populated by calculations based on the defined four criteria, but in order to take advantage of expertise and experience of security experts, we have got it filled from them.

The value of Consistency Ratio comes out to be less than 10%, which shows that our approximation is good enough, /18/. Based upon this fuzzy comparison matrix and using Eq.(1), the corresponding ranks and weights are calculated as given in Table 6. The value of Agility Indicator for each agile method is also shown in Table 6.

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

Thus, the ranking order in this case has come to be CRYSTAL > SCRUM > XP > LEAN > DSDM > FDD and thus we can categorize these methods into two broad categories, the one with more liberal methods like Crystal Clear, Scrum, XP, Lean development and the other with the more heavy agile methods like FDD and DSDM.

Table 3. Normalized values of selection criteria and calculation of agility indicator.

Criteria	Weights	LEAN	SCRUM	CRYSTAL	XP	DSDM	FDD
Level of formalization	0.225	1.000	0.500	0.400	0.333	0.286	0.250
Rigidity to change	0.323	0.250	0.500	0.333	1.000	0.125	0.111
Process cost	0.214	0.167	0.250	1.000	0.333	0.125	0.143
Project complexity and reliability	0.238	0.778	0.556	0.222	0.444	1.000	1.000
Agility indicator		5.31	6.41	7.22	6.74	1.99	1.66

Table 4. 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)

Table 5. 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 project complexity	(1,1,1)	(0.2,0.33,1)	(0.2,0.33,1)	(1,1,1)

Table 6. Calculation of agility indicator.

	Weights	LEAN	SCRUM	CRYSTAL	XP	DSDM	FDD
Level of formalization	0.175	EI	SI	SI	SI	VSI	ESI
Rigidity to change	0.479	MI	MI	MI	EI	ESI	ESI
Process cost	0.229	SI	MI	EI	MI	VSI	VSI
Project complexity and reliability	0.146	VSI	SI	MI	MI	ESI	ESI
Agility indicator		5.34	6.39	7.16	6.8	1.79	1.37

PROMETHEE. As another approach for choosing the most suitable agile method, we have used the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) method which follows the various steps as described in Fig. 2.

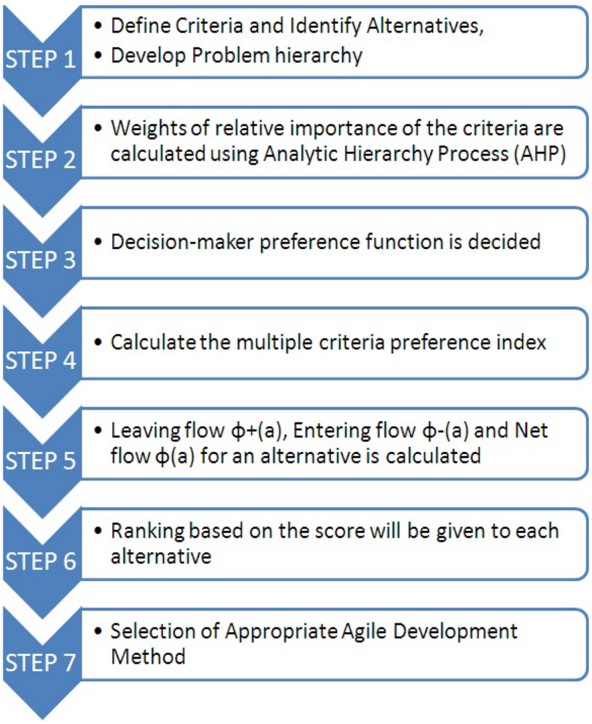

Figure 2. PROMETHEE process flow.

The criteria and alternatives are already defined and the weights are calculated in the previous sections using AHP, /19/. After this the next step is to evaluate the preference indices along with: entering flow; leaving flow; and net flows, as shown in Table 7. The preference ranking is calculated based on Eq.(4) and the entering, leaving and net flows of the given alternatives are calculated based on Eqs. (1), (2), and (3), respectively. From the calculations, it has been found that the Scrum has come out to be the best choice among all other alternatives, according to the present scenario of selection of best agile development method. The net flow is also represented in the form of a graph, as shown in Fig. 3.

$$\phi^{+}(a_i)=\sum_{j=1,j\neq i}^{n}\Pi(a_i,a_j) \tag{2}$$

$$\phi^{-}(a_i)=\sum_{j=1,j\neq i}^{n}\Pi(a_i,a_j) \tag{3}$$

$$\phi^{net}(a_i)=\phi^{+}(a_i)-\phi^{-}(a_i) \tag{4}$$

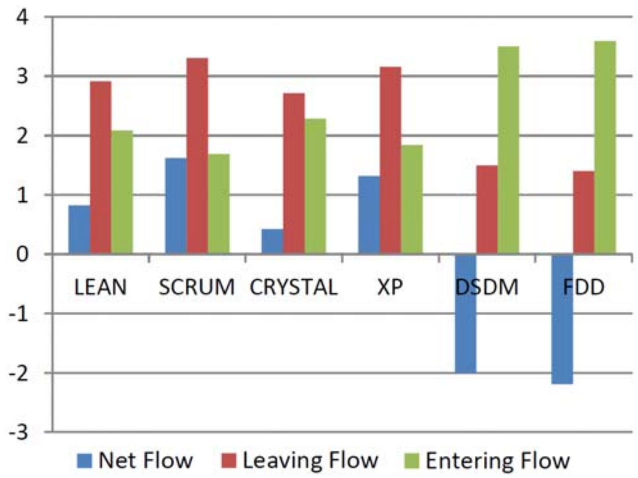

Figure 3. Comparative representation of flows.

In the last step, based on the net flow, sorting is done for the final ranking. The ranking order of the agile methods comes out to be Scrum > XP > Lean > Crystal > DSDM > FDD.

Table 7. Resulting preference indices with leaving, entering, and net flows.

	LEAN	SCRUM	CRYSTAL	XP	DSDM	FDD	$\emptyset^{+}$	NET Flow	Ranking
LEAN		0.463	0.463	0.463	0.762	0.762	2.913	0.826	3
SCRUM	0.537		0.786	0.463	0.762	0.762	3.31	1.62	1
CRYSTAL	0.537	0.214		0.439	0.762	0.762	2.714	0.428	4
XP	0.537	0.537	0.561		0.762	0.762	3.159	1.318	2
DSDM	0.238	0.238	0.238	0.238		0.548	1.5	-2	5
FDD	0.238	0.238	0.238	0.238	0.452		1.404	-2.192	6
$\emptyset^{-}$	2.087	1.69	2.286	1.841	3.5	3.596			

Table 9. Ranks calculated from different approaches.

Ranks	1	2	3	4	5	6
AHP	CRYSTAL	XP	SCRUM	LEAN	DSDM	FDD
Fuzzy AHP	CRYSTAL	SCRUM	XP	LEAN	DSDM	FDD
PROMETHEE	SCRUM	LEAN	CRYSTAL	XP	DSDM	FDD
Fuzzy PROMETHEE	SCRUM	XP	LEAN	CRYSTAL	DSDM	FDD

Similar to the original PROMETHEE approach, in the final step, sorting is used for the final ranking. The order of the ranking of different agile methods turns out to be Scrum > Lean > Crystal > XP > DSDM > FDD.

Rank Aggregation Method. When we have different rankings from different methods then in that scenario there are a number of options for aggregation, none is really better than the other, but depends on the requirement. One approach is to take the average and rank the averages, another approach could be to find the median and rank according to that, there is one other approach of voting. There are so many methods available but we have used the first approach to demonstrate the rank aggregation as shown in Table 10. The ranks obtained from different methods are compiled in Table 9.

Fuzzy PROMETHEE. In order to compensate the subjectiveness in decision maker preferences, we have modified the PROMETHEE by using Fuzzy AHP and Fuzzy PROMETHEE to choose the most suitable agile development method.

Table 10. Rank aggregation.

Agile method	Average rank	Final aggregate ranking
LEAN	2.17	4
SCRUM	1.17	1
CRYSTAL	1.50	2
XP	1.83	3
DSDM	3.33	5
FDD	4.00	6

CONCLUSION

This work provides a multilevel hybrid approach for agile development method selection according to the requirement of a particular project. As there was not much empirical work done on this regard, so we have applied the widely used and accepted methods as AHP, PROMETHEE and Fuzzy logic, thus providing the much awaited authenticity and reliability, which sometimes is questioned in case of the agile approach. We have used agility indicators to measure the agility for ranking and at the end – rank aggregation method is used for final ranking. We hope that this work would open a new horizon in this field of agile development and will prove to be a pivotal point for agile development method selection, and will help to generate better results in the future for this field.

For future work, Artificial Neural Network (ANN) can be used for producing accurate results even for some imprecise inputs, as ANN has the ability to generalize and produce accurate results, even for corrupted data.

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