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Literature Review on Requirement Prioritization Methods

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***Abstract* --**Requirement Engineering is a very important phase in SDLC. The success and failure of the end product has direct connection with this Requirement Phase. So the output quality of this phase plays a vital role. Requirement Prioritization Process (one of the process) in this phase helps the engineers to work out and find the prioritization among the requirements. Because of the constraints – cost, time and other factors, prioritization plays an imperative role in the development of project and also to improve the goodwill of the company in the competitive market. In this paper, the Requirement Prioritization techniques are discussed and research articles related to the topics are reviewed. Based on the analysis of previous research, the comparisons between the mostly used models are made, drawbacks and strengths are discussed.

Keywords: Requirement Prioritization, AHP, Prioritization techniques

I. INTRODUCTION

SDLC (Software Development Life Cycle) has six phases which includes requirement phase, system specification, system design, programming and coding, testing and maintenance. Among these phases of software development, requirement engineering is considered as most important phase because the triumphant completion of the software system with efficiency, usability, reliability, suitability and maintainability mainly depends on this phase[1].

The main aim of any software company is to satisfy the stakeholders demand. Only then, they can stay in the market. Hence, the requirement phase is considered as first and the important phase in SDLC and it is convoluted too [2].
Due to the errors unsettled at this stage, if detected in the last stage of software development will be very costly. The processes in this phase are given in figure-1.

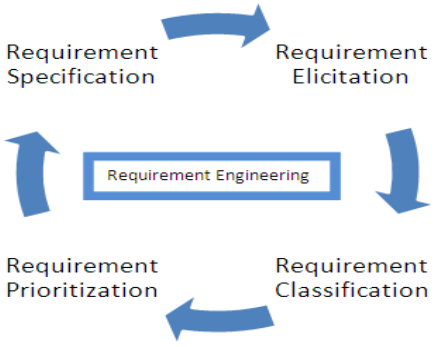

Figure-1. Process of Requirement Engineering

In this phase, the first process is requirement elicitation in which all the requirements are collected from the stakeholders. Then comes requirement classification process (Figure-2). Here, the requirements are first categorized in to functional requirements and nonfunctional requirements(NFR).

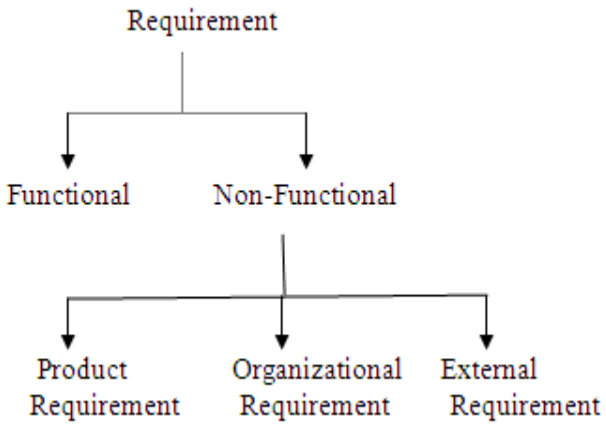

Figure -2 Requirement Classification

After classification, requirements have to be prioritized to know about the group of requirements that has to be developed first to gratify the stakeholders [3]. This prioritization process helps the decision makers for a precise release with the selection of requirements having high importance and high business value. When the resources are limited, time given for the development is less and the

customer's expectation is high, the prioritization process guides the developers to trounce these challenges.

To prioritize the requirements, many methods are available. Those techniques are broadly categorized in to three types (Figure 3).

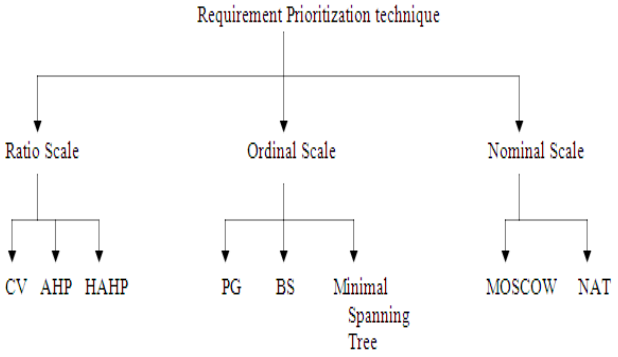

Figure 3 Requirement Prioritization Techniques

As a part of our research work, in this paper we have discussed and analyzed about requirement prioritization techniques which come under the first phase of SDLC. Section I contains introduction about the requirement phase, Section II of this paper explains the available Requirement Prioritization methods. Section III shows the analysis of those methods and approaches with the help of related research articles. Section IV describes the comparison among those methods. Section V contains the conclusion about the evaluation process and Section VI discusses about the future work.

II. PRIORITIZATION TECHNIQUES

This section presents a narrow view about the available Prioritization techniques.

❖ **Numerical assignment techniques (NAT)**

This mode is frequent in quality function deployment. One of the appropriate approaches for this technique is suggested by Brackett [4]. According to him the requirement has to be sorted as,

(i) Obligatory,
(ii) Desirable or
(iii) Not essential.

The numerical value on a scale ranging from "one" to "five" will be assigned to the options. For example the value 5 will be given for the option ` Obligatory', 4 for `Important', 3 for `better if available", 2 for `not essential' and 1 for `No problem'. Based on these ideals the requirements will be prioritized.

❖ **Bubble sort (BS)**

Since it is used to sort `n' elements in an array, it is also used to find the priority among 'n' requirements [3]. In this method the requirement is taken and compared with another, and swapping will be done between the requirements based on its priority. Finally, the sorted list based on priority will be obtained. This takes lot of comparison between the requirements. If the requirement list is soaring then it is difficult to adopt this method.

❖ **Binary search tree(BST)**

This method was specified by Hoperoft Aho & Ullman [3]. It is also presented by Kartson [3]. According to this method, each node represents a requirement. Left node for less priority and right node for high priority requirement. First taken requirement will be considered as a base node, then the next requirement will be compared with that, if that node is lower than the first one, then it will be positioned in its left bottom, otherwise that will be a right bottom node for the first node. All the requirements are compared and placed in the respective place and the level. Through this, the priority of the requirement will be decided.

❖ **Hundred dollar method.**

In this method, 100 dollars given to each stakeholder has to be strewn among the requirements. The stakeholders can distribute these points among the requirements based on his/her own decision. It is also referred as cumulative voting [5] except weight is not assigned to the stakeholders.

❖ **Simple ranking**

This was presented by Bernades & Halton and Andrews [6]: All the K requirements are simply ranked from 1 to K. Most important requirement starts with 1 and ends with the least requirement with K. This effortless technique is based on ordinal scale.

❖ **Moscow.**

Under this, the requirements are grouped into 4 categories, Must have, Should have, Could have and Wont' have[6]. The result of this method is on a nominal scale. The requirements in one group are considered as having equal / same priority. But the priority among the requirements in a particular group will not be find.

❖ **Value oriented prioritization (VOP)**

In this, the parameters of business value are identified and the matrix is framed with the requirement list. If there is 'n' number of R Requirement and 'm' parameter of 'B' business value, then n x m matrix is framed. For each requirement the business value will be related and weight will be assigned in an ordinal scale 'w'. Finally the priority 'p' for the each requirement 'R' will be calculated. This method will be thriving if proper weight is assigned by the stake holder.

❖ **Analytical Hierarchical Process (AHP)**

This method was developed by Soaty [6]. In AHP the entire requirement are compared with one another. Since pair wise comparison of all requirement are required, the software with 'k' requirement needs k(k-1)/2 comparison [6]. It can be used only for the few stakeholder, but it is not possible practically. This method is not suitable for the software with hefty number of requirement. It also adds extra efforts for decision makers [7].

❖ **Planning Game (PG)**

In this, the stakeholder will be given the category to cluster the requirement. For example, if it is divided into 3 category : 1. The system can only function with these requirements, 2. Those which have high business value, and 3. It will be good if it is there [4]. The stakeholder has to settle on and place the requirement card in the group. In this, each requirement has to be compared with 3 categories, so 3 x k comparisons are required. In the meanwhile, the programmer will estimate time, risk and cost for each requirement. So 3 x k comparison will be made here also. Then they will decide the category to be considered for the next level delivery of the product. Hence this method requires the following number of comparison.

$$NC = S (c \times r) + P (c \times r)$$

NC-Number of Comparisons, S – Stakeholder, c – Category, r – Requirement, P – Programmer

❖ **Hierarchy AHP**

As AHP Method requires large Number of comparisons, the method introduced by Karlsson et al [6] is to lessen the number of comparisons. High priority requirement will be placed in the top and low priority requirement takes place in the bottom level. All the given requirement will not be compared pair wise . Hence the number of comparisons will be compressed among the requirements.

❖ **Requirement Triage (RT) [7]**

Also called priogrov, has 3 stages to get the list prioritized. First, the gathered requirements are clustered based on features using clustering methods. Then these clusters are prioritized using some prioritization technique manually. In this method, the Priority of the requirement is calculated by,

$$PS_r = \sum_{i=1}^{|c|} Pr(C_i \mid r)\, RC_i$$

PS_r- requirement's prioritization score, C – cluster, r – requirement,

III. LITERATURE REVIEW - RELATED WORK

Suleyman Kivance Ekici et al [2], presented a systematic study on the popular approaches – MOSCOW, AHP and NAT. First, criteria are prioritized using AHP, then business value computation for each requirement is done. The authors suggested the future work as considering managers and their hierarchy in calculating the business value for each requirement , defining profiles of the end user and categorizing them to include weights for the user and to conduct frequent meeting to reevaluate the prioritized requirement.

Javed Ali Khan et al [3], assessed the prioritization techniques by reviewing research papers and finally they came with the result that AHP is the best requirement technique among all. It is concluded that, AHP requires more comparisons of requirement. This is very difficult to handle in the very large scale projects. Hence tool support is required.

Hadeel E Elsherbeincy et al [8], aimed to prioritized requirement with statistical analysis for large scale system. The RateP method is implemented in the dataset which contains 76 stakeholders, 48 requirements, 10 project objectives and 104 specific requirements. Frequency and percentage of the requirement is calculated. Mean rate is found out. Then the Spearman's correlation co efficient between the requirements is calculated to obtain the prioritized list. Comparing the results obtained between different statistical methods is given as future work.

Mohammed Alkandari et al [9], proposed a model after evaluating the existing prioritization models. The new model is considered as a generalized model to prioritize requirements for all type of projects. The suggested future work is to apply this model in the project..

Syed Ali Asif et al [10], proposed a framework. This will reduce human interactions to prioritize and reprioritize requirements. The proposed model is implemented in ralic dataset and proved that it requires less human interactions than other. The future work suggested is to cluster the framework and the stakeholders and can extend the framework by including clustering techniques.

Joachim KArlson et al [11] developed an analytical tool for prioritize the requirement based on cost-value approach to rank requirement in two dimensions – its value to customers and to end users. This method was implemented in two projects. It also considers the cost to be included for the requirement.

Nasir Mehmood Minhas et al [12], in this paper, proposed a new technique which has five steps, and that considers stakeholder's and requirement's weightage for global and distributed software development. For software release, the automated procedure is used to come with the requirement with prioritization. Negotiation of requirement will be

considered among the stakeholder who resides in various countries. Integrated approach was proposed.

Manju Khari et al [4], compared the existing requirement prioritization techniques by applying that in the projects. They have considered AHP, VOP, NAT, BST and PG for their study. The parameters taken are accuracy, number of comparisons essential, overall time taken and simplicity of use. They came out with the result that VOP entail least amount of time and gives precise result.

Samina Saghir et al[13] compared the techniques AHP,VOP, CV, VOP, BST and NAT. The new framework for global software engineering was proposed,. In this research, the human collaboration was diminished. Variables relevant to GSE such as risk, time, cost, importance, etc., are considered. It has six steps.

M Sowmya Krishnan[14], It is very complicated to categorize NFR like risk, benefit, effort, cost, dependency, etc., After comparing the existing prioritization methods, a model was proposed with three layers of priority- Top, Middle and Bottom. Stepwise functioning of the proposed model explained and proved that it is suitable to prioritize the requirement.

Khurram Ejaz et al [15], the analysis of the existing prioritization models was made and new approach of requirement prioritization was proposed to overcome the drawback of existing models. As a result, the new model is proved as simple and very useful in prioritizing the requirements.

Mona Batra et al[16],this study examines the requirement prioritization methods. Frameworks and practices in the current trend. Few related papers were analyzed and presented the future research scope in this area.

Mulugu Narendhar et al[6], the requirement prioritization methods are somewhat difficult to implement for large scale projects. Hence the technique that addresses this limitation has to be framed to support all type and various scale projects. AHP and BS are producing reliable result but consumes large amount of time and effort. But other techniques have accuracy problem.

Syed Zeeshan Hussain et al[17], proposed a method for requirement prioritization with the help of decision tree which takes cost as a only important criteria. In future, more than one criterion has to be considered. Fuzzy method should be used to find the requirement prioritization.

Anuj Soni [18] evaluates the requirement prioritization methods. The author considered certain number of parameters to select the appropriate requirement prioritization method. In this, multi criteria decision making approach is used to select the prioritization method.

Shahid Nazir Bhatti et al[5],evaluated related papers to analyze the requirement prioritization methods. AHP yields better result than others and very useful in decision making. Finally, proposed hybrid requirement prioritization model with the detailed presentation of proposed model. Future work is suggested as complete automation of software engineering process. And also concluded that the existing prioritization techniques are not applicable for all types of projects.

Zahi Abu Sarhan [19] , describes the method AHP as the best in reengineering projects. It can handle the multi criterion problems. AHP is used to consolidate the evaluated data. AHP is effective when the number of criteria is few. So it has to be used with the combination of other decision tools. It also requires more calculations. Hence tool support is required.

Tschangho John Kin [20] , modified or alternative approach for AHP was proposed. Excel spread sheet is used to calculate which is suggested as a easy method.

Hamed Taherdoost [21], this paper presents about the functioning of AHP. Stepwise detail explanation of AHP is specified.

IV. INTERPRETATION

Author	Year	Contribution	Limitation
Suleyman Kivance Ekici et. al [2]	2016	Framed a structure for requirement prioritization	It doesn't consider higher level authorities and there is no categorization of users. More criteria is required.
Javed Ali Khan et. al[3]	2015	Comparisons between requirement prioritization methods were made with the conclusion that AHP is the more suitable one.	Tool support is not available
Syed Ali Asif et. al [10]	2017	Requirement prioritization framework is proposed and implemented	Clustering of requirement and stakeholders are required
Samina Saghir et. al[13]	2016	Comparison of the requirement prioritization models were made	Features should be added in the proposed structure to grant weightage for the stakeholders from different areas
M Sowmya	2018	Study on various	Non functional

Krishnan [14]		prioritization methods were made and proposed a solution as a model for large scale projects	requirement should also be considered for prioritization
Khurram Ejaz et. al [15]	2016	Analyzed prioritization techniques. Presented its drawbacks. New approach was proposed	Tool is required as an intelligent system to prioritize the requirements automatically.
Zahi Abu Sarhan [19]	2011	AHP is effective when number of criteria is few	Tool support is required

Table 1. Comparison of existing work

After conducting literature review, this research work extracted five parameters for the prioritization methods.
The parameter **Speed** is considered as one of the important characteristics of the prioritization methods. BST and BS takes higher position and AHP takes the next higher position among all prioritization methods.

The next parameter is **Implementation Simplicity**. This parameter is very important to make the stakeholders to cooperate in the prioritization process. BS and Moscow are in the higher position followed by AHP and BST in this parameter.

Another parameter is about using the method for **Large Scale Application**. In this characteristic, BST stands in the advanced position followed by all the further methods AHP, NAT, BS and Moscow.

Subsequent parameter is **Accuracy**. Accuracy of result is very essential to adopt the method for operation. If implementing the method is trouble-free and very economy but the result produced by that method is not accurate, then there is no use in adopting that method to prioritize the requirement. Hence this parameter is considered as a key one. Here AHP stands in a privileged [3] position followed by NAT and BST.

The last parameter considered is the **Stakeholder's Participation**. Without stakeholders partaking, no company can prioritize the requirements. But the level of participation should be measured. If it requires large number of stakeholder's participation, it may consume time to conclude with the prioritized list. Hence minimum number of stakeholders participation is contented for the development team. Under this, AHP rests in the higher spot followed by BST and BS.

Apart from these parameters, **Tool Support** for all the prioritization methods is weaker. If the proper tool support is available, then it will be very easy for the development team to get the prioritized list of requirements.

V. CONCLUSION

As requirements crop-up throughout the software development process, prioritizing the requirement is significant in large scale projects. Among all the methods, AHP is feasible but not for large scale projects. Hence the generalized method has to be developed. The above discussed parameter has to be improved in that generalized method.

VI. FUTURE WORK

The future work of the research is focused on developing the model which adopts the features of the existing methods and also with the features to overcome the limitations of those methods to prioritize the requirements. The model should also be suitable for large scale projects which are considered as a very big challenge.

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