

Requirements Prioritization: Challenges and Techniques for Quality Software Development

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Abstract

Every organization is aware of the consequences and importance of requirements for the development of quality software product whether local or global. Requirement engineering phase of development with focus on the prioritization of requirements is going under huge research every day because in any development methodology, all requirements cannot be implemented at same time so requirements are prioritized to be implemented to give solution as early as possible in phases as scheduled in incremental fashion. Numerous frameworks and practices have been devised, in progress and some being discovered day by day. With such huge knowledge database and research available, it has always been confusing to decide which technique to follow to gain maximum results. Thus many projects fail because of the wrong choice in requirement prioritization because it's really difficult to employ right technique and framework at right time. And problems do not end here rather due to strict deadlines, it's often best to develop system in parts by different team members dispersed globally with diverse methodologies and differences and in this situation it becomes more difficult to prioritize requirements. Main focus would be on ETVX based prioritization [1] for in house development and requirement prioritization of software developed globally by diverse team members [2]. This paper will try to provide an overview of different prioritization techniques for software requirement, and a critical analysis of ETVX based model will be presented to highlight issues and challenges in this proposed model of requirement prioritization in [1] and improved version of this model will be presented while an analysis of requirement prioritization for software developed in global environment [2] also be presented.

Keywords: Requirement prioritization; Prioritization; Prioritization techniques; Requirement engineering; HCV; prioritization framework; Global software development; GSD

1. Introduction

Software engineering has introduced new techniques and frameworks for quality software development. With the time, software development community and professionals has understood the importance of software engineering activities to be followed for quality software development which saves time to produce the quality product at right time. Software engineering process includes many activities where a product is engineered. There are different flavors and versions of these frameworks but every framework or

sequence incorporate some basic activities in the form of a basic process in fig 1.

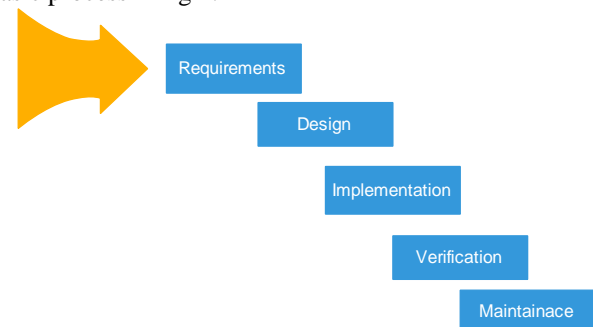


Fig 1 Basic Software development activities

In any development framework the starting point is always the requirement for the product being developed. And as the software nature and scope changes, requirements are bound to be changed and it's the only part of the software engineering that is considered more difficult as any adjustment in this stage will affect the final product. Wrong requirement will be implemented that is not desirable. That's why requirement engineering process is necessary to be well followed to evade these problems.

For small projects requirement engineering is easy to be incorporated in development but as the size of the project increase, requirement becomes trickier to understand and complexity, ambiguity of requirement increases. In requirement engineering process there are certain activities to be followed as in figure 2 which include requirement gathering as first activity, negotiation, requirement specification, validation and requirement document at the end.

Activities shown in figure 2 are essential to be followed in requirement engineering process where requirements are gathered, analyzed, negotiated, validated and documented for further use. Each activity is equally important in entire process and has a deep impact on other activities in engineering process. And final product of this stage, requirement document serves as a blue print and design

guideline for software designers and developers in afterward stages of software development.



Fig 2 Requirement engineering process

Due to strict deadline of project completion, project managers use incremental model to develop the software product where product is built in modules where each module is integrated with other module in final product while individual module has its own functionality alone. In such situations it's required to prioritize the requirements to meet the deadline as some requirements must be completed than other. So requirements are prioritized according to their importance in the software by following certain rules and regulations to gain maximum results in minimum time. Another approach to complete the development within time is global software development where different teams which are geographically spread works on the software products as a whole or module by module to complete the project within time and budget constraints. Approaches, global development of software and development in local environment has their own pros and cons with own goals and objectives. But in any case requirements must be prioritized to accomplish the tasks efficiently.

Distributed software development is different in a sense that development team and stakeholders are geographically dispersed with different cultures, environment, language, time zones and development techniques which hinders in quality software development as in requirement engineering phase both the stakeholders and development team has to interact which each other for requirement gathering, clarification but communication gap and other aspects explained in later part limit this interaction. Yet these barriers can be removed but our main focus would be on the integrated requirement prioritization technique introduced by [2].

This research paper is divided in different sections. In section 2 research problem will be stated for which whole research has been conducted. Section 3 will have research

methodology and research question. In section 4 related works in requirement prioritization will be presented to show the researches in requirement engineering phase to prioritize the requirements. In later sections some requirement prioritize techniques will be presented then there will be a complete analysis of ETVX based requirement prioritization and requirement prioritization in global software development will be presented with limitations and challenges of these techniques and proposed solution will be presented.

2. Research Problem

RQ: What are latest software requirement prioritization techniques and challenges and what are tools and framework for requirement prioritization technique for quality software development locally or globally?

3. Research methodology

To answer the question on which my research is based, I performed extensive literature review according to the research guidance provided by B Kitchenham [3]. According to the guidelines and research methodology I searched different research papers on the topic of software requirement prioritization techniques. There is a bulk of data available online presenting different techniques for software requirement prioritization for in house development and for global or distributed software development. So in first search I found many research papers then I shortlisted some of them fulfilling my research topic. Many research papers are presenting comparative studies while in some papers, new techniques for software requirement prioritization are proposed.

3.1 Searching Strategy

Initially I searched for software requirement prioritization which includes both the in house general software requirement prioritization and requirement prioritization techniques for software developed with diverse team members and stakeholders. To broaden and enhance my understanding about software requirement prioritization so that essential concepts might not miss. To make sure I get relevant research papers with detail analysis of emerging software requirement prioritization techniques , every possible search was conducted in IEEE explore digital library , Google scholar and third part research paper providing libraries such as Research Gate.

3.2 Selection

After studying basic software requirement prioritization it was necessary to shortlist research papers on software requirement prioritization domain describing new

frameworks for both local and global requirement prioritization which reduced number of research papers.

3.3 Study Methodology

Instead of pure analysis of software requirement prioritization techniques comparatively, main focus was on understanding the software requirement prioritization techniques and to comprehend the situations in which any technique is applied. So to focus on the result an overview and essential detail of some new and already used techniques is presented in this paper to answer the research question. Fig 1 shows basic model followed for the research paper.

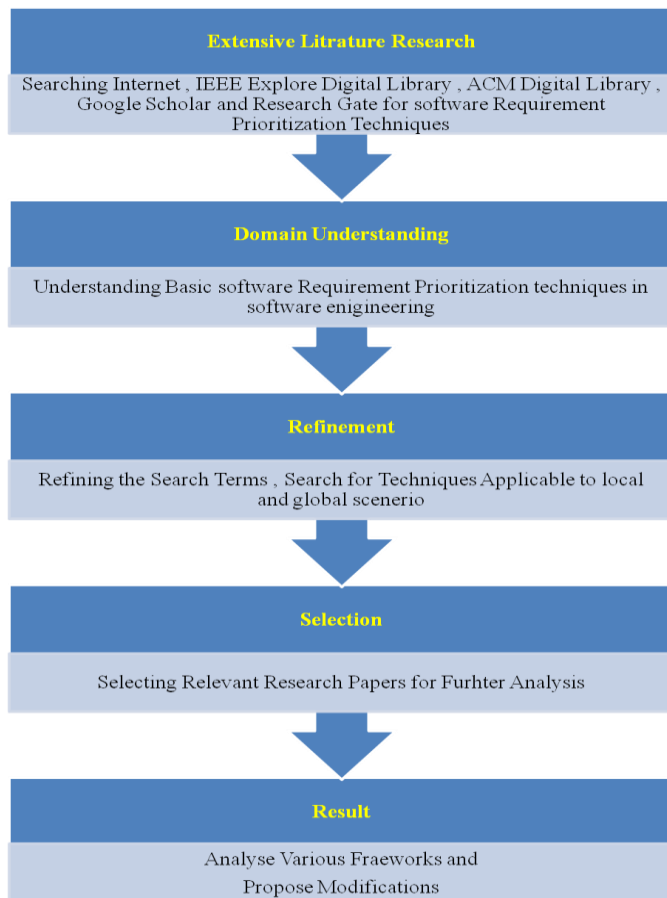


Fig. 3 Basic Model for Research

4. Related Work

Enormous research is conducted on the requirement prioritization techniques and methods in requirement engineering process. There are numerous techniques available today for prioritization each with different criteria and pre conditions. Still a lot of research is being carried out on this problem of efficiently prioritizing requirements.

A framework proposed in [4] for software requirement prioritization utilizes an unique approach to prioritize requirements which have been missed due to any reason in classic prioritizing techniques by inter perspective relationship by using a matrix. This unique method measure the contact between requirements using relationship matrix based on the priorities of these requirements in relation to other requirements with diverse perspectives. Thus help understand the behavior and relationship of requirements with other requirements in relation to their founding stakeholders which eliminate any miscommunication. Another fascinating technique by Boehm and Kukreja [5] prioritize requirements in each cycle of requirement change as it incorporate complete change management system along with prioritization. This method is best suited for performance critical software products where requirement gathering phase is generally longer to get perfect results.

5. Requirement Prioritization Techniques

Healthy research has been conducted on prioritization of requirements in software development. Here in this section some of unique techniques will be discussed which has excellent results in prioritizing requirements and I will be proposing one of these techniques to be integrated in ETVX based model of requirement prioritization in later section.

5.1 Analytical hierarchy process

Main theme of this approach is to modularize the requirements by splitting requirements in sub requirements which results in a hierarchy of requirements as in fig 4. Here requirements are broken down into sub requirements and prioritizing sub requirements will result in prioritizing main requirement which helps in decision making process by assigning values to the requirements in hierarchy. Research has been conducted on this simple technique and there are many modified versions available.

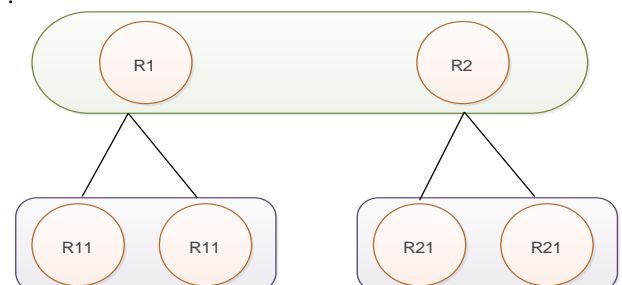


Fig 4

5.2 Cumulative Voting Prioritization

This technique of prioritization of software requirement is based on a ratio scale which is used by involved stakeholder prioritizing the requirements that prioritize requirements using some fixed numbers and they assign these numbers to requirements using voting according to goals, features and objective of requirements. In this way a requirement which has greater weight in terms of greater number of votes is considered as most priority requirement. In this approach multiple stakeholders vote in this process.

6. Hierarchal Cumulative Voting

HCV Hierarchal cumulative voting technique as described in [6] is a unique approach to requirement prioritization which fulfils the gap that has been left behind by Analytical Hierarchy process AHP and cumulative voting technique. It's built to overcome the shortcomings of AHP and CV. By promoting hierarchy it combines the benefits of cumulative voting technique by supporting multi decision support just like AHP. It works by providing relative priorities to requirements by using ration scale which enables to calculate relative importance of requirements. Also a distinguish feature of this technique is the calculation the ratios between different aspects which are combined by this techniques. Basically it helps calculating cost value ratio for priority calculation. Thus it prioritizes requirements at different levels. Figure 5 shows detail where requirements are distributed at different levels according to the relative points criteria set by technique and requirements in same block are prioritized.

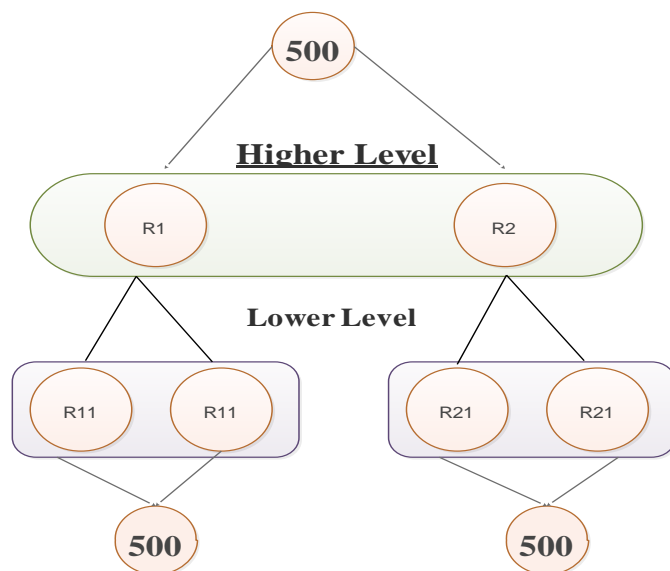


Fig 5 HCV

7. ETVX Based Model Prioritization

Here in this section proposed framework as defined in [1] will be summarized. Entry task validation and exit based requirement prioritization framework has been proposed by author in [1]. Author claims it to be a complete package for software development and requirement prioritization in requirement engineering. Proposed framework is presented in figure 6. Originally this technique was developed by IBM international and after that it has undergone research. According to the author this process model can be used to prioritize requirements in software development. Proposed framework has following sequence of steps.

7.1 Entry

In the entry step of model initial needs of requirement prioritization are defined with respect to purpose and objective. Beside these specific goals, roles and responsibilities of requirement gathering, refinement and prioritization are assigned along with documented process procedure with budget and schedule planning documentation. Beside these goals entry section comprises of following specific activities.

- 1) Requirement Gathering: Basic requirement elicitation task are carried out in this step.
- 2) Requirement Identification: Requirements are identified by expert panel of quality assurance and requirement gathering team panel to exclude any unwanted requirement.
- 3) Requirement Refinement: Requirements are further refined to remove any ambiguity by highly expert team.
- 4) Requirement Separation: Requirements are classified into modules according to functionality possessed. Atomicity of requirement is judged by requirement engineers along with the classification of constraints on requirements.
- 5) Stakeholder Identification: As requirements are prioritized by grouping of stakeholders, here stakeholders are identified and grouped together such as system developers, marketing personnel, management, end users and finance group.

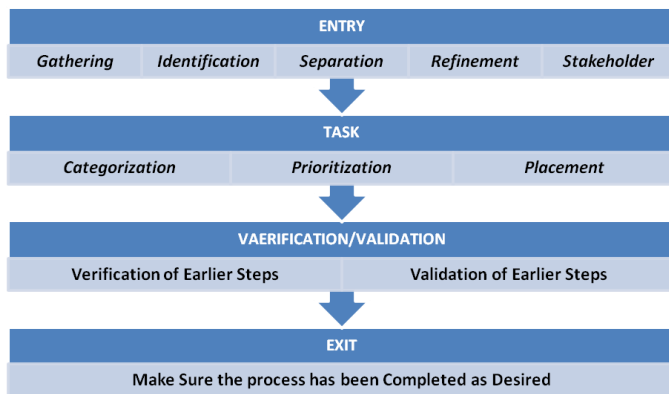


Fig. 6 ETVX

7.2 Task

This part of framework has been categorized as actual prioritization part of framework where actual requirement prioritization activities are followed.

1) Requirement Categorization: Requirements are categorized according to the priority level defined. In each module there reside requirements with priority level. Thus it provides structure to place prioritized requirements.

2) Requirement Prioritization: In requirement prioritization stage of this framework, stakeholders set priority level of each requirement and requirements are put into groups according to stakeholder's priority level which is core theme of this framework. For priority settings, numerical value and statistical analysis is used. Requirements engineering team set priority level factor for each stakeholder and it's assumed that developers and end users have high priority than financiers or marketing team.

3) Requirement Placement: Requirements with defined priority are kept in separate classes and if found any problem, requirements are sent back to stakeholders for setting priority.

7.3 Validation

Purpose of this step is to ensure previous activities have been completed according to organizational standards. Further detail is presented in [1].

7.4 Exit

Process is terminated after verification and validation process and by ensuring no pending tasks and by ensuring if any rework is required and by ensuring all requirements are prioritized. Exit criteria consequences in prioritized requirements.

8. Critical Analysis of ETVX based Model

Proposed ETVX based model looks good on paper but it lacks many features and some steps need refinement such as

it does not define the method to be used in stakeholder identification. Main limitation of the proposed model is the prioritization step. It's clearly unstructured as according to the model requirements are first categorized according to the priority level without first defining and prioritization method. It's unrealistic to categorize requirements without any prioritizing which is the main requirement for the development of this framework and it's not fulfilled. Again in prioritization step requirements are prioritized by stakeholders using numerical values and statistical method but author could not define which kind of numerical value method to employee or which kind of statistical method to use to prioritize requirement.

Also according to the author Requirements engineering team set priority level factor for each stakeholder and it's assumed that developers and end users have high priority than financiers or marketing team but again it's unrealistic as its well established fact in requirement engineering that each stakeholder's requirement has its importance in shaping the final creation and we cannot prioritize stakeholders in such fashion that bring conflicts in requirement engineering phase. There is no conflict resolution stage identified in the entire model as no matter how much cleaner the process is, conflict is bound to happen and if it happens, requirements are bound to negotiate and change becomes mandatory. But there is no change management with traceability of requirements. It's unrealistic to prioritize requirements using merely numerical and statistical values.

9. Proposed Solution

Proposed framework has serious limitations and it's unable to justify its results. So to overcome issues in the framework I have proposed solution to some of problems in framework. As described in critical analysis of ETVX based proposed model, task section of model is very confusing and unrealistic so to make it realistic, categorization stage must be after the prioritization stage and when it happens, there is no need of placement stage because when the requirements will be prioritized, they will automatically be categorized in a sequence.

Prioritization process is unrealistic so to make it realistic enough, I propose to use HCV Hierarchal cumulative voting technique in place of simple numeric or statistical values. By this technique, requirements would be prioritized in a hierarchal manner to be categorized and placed in a hierarchy. So it will solve the issue of categorization, prioritization and placement of requirements.

When stakeholders are involved in prioritization of requirements, conflicts are bound to happen, which leads to requirement change but in original model there is no conflict ruling, change management. So to overcome these issues I suggest including negotiation, change management

and traceability in proposed solution so that when conflict arise , there must be conflict resolution which leads to requirement change and that change can be managed and traced by requirement change management and traceability. Proposed solution model is presented in figure 7 where task section of ETVX model is modified to get realistic results. There are also other changes in entry and validation stage of this model but main focus was on prioritization so that has been fixed and rest is for future work.

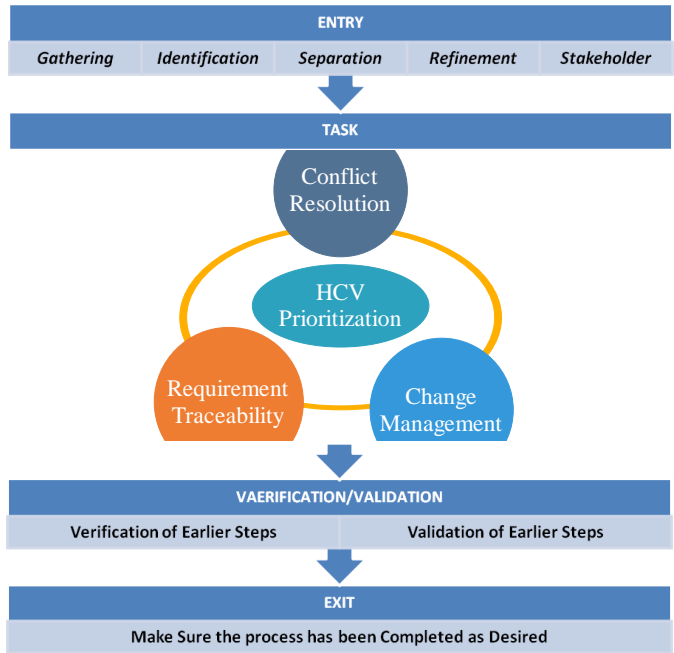


Fig 7 ProposedSolution to Prioritization Phase

10. Global Software Development

Traditionally software development team and stakeholders are available at one place to interact with each other in different phases of software development. Sometimes it's needed to employee team members, part of team from geographically dispersed area to overcome technical issues as it enhance workforce diversity. Example of such condition is the freelancers work around the globe while contractor and freelancers, companies hiring freelancers are geographically dispersed. This trend has been increase since last ten years to complete the software product as early as possible, within the budget constraints. Despite benefits of global software development, problems and challenges are there. Solutions are also available to rise above these challenges. Teams and stakeholders in different areas face communication, time zone difference, language and many other issues as in figure 8 as described in detail in [2].

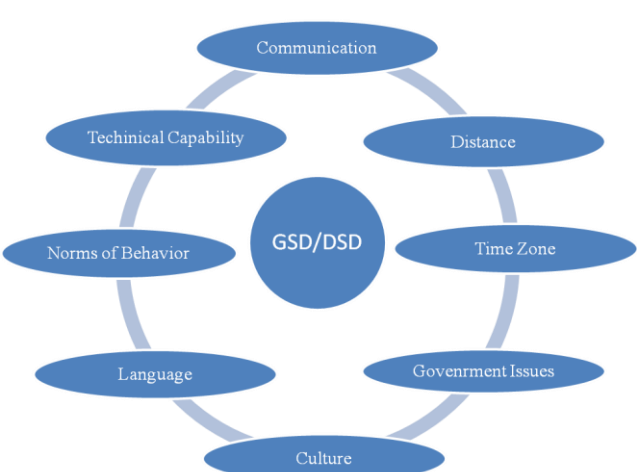


Fig 8 challenges to global software development

Despite these challenges, softwares are being developed on multiple sites where developers, requirement engineers, stakeholders and management does not need to be at one place. Yet there are issues in requiremnt prioritization in this kind of software development. To remove these prioritization issues author introduced an integrated framework for requirement prioritization. A basic model of proposed framework has been drawn in figure 9. Basically this framework is a 5 staged model whose main idea is to prioritize requirements by keeping in view the weigtage of stakeholders and requirements itslef which enhance the prioritization method. Basic detail of proposed model is described below.

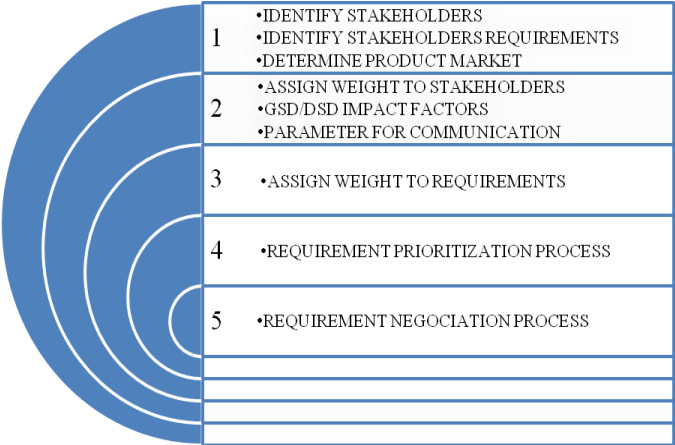


Fig 9 integrated framework for global software development

10.1 Stage 1

Framework starts by identifying potential stakeholders of software product being developed.

1) Identify Stakeholders: Due to global software development stakeholders might not be at one place, they can be anywhere around the globe such as developers and users from different geographical area. So here potential stakeholders are identified

2) Identify Stakeholder's Requirements: After stakeholder identification, requirements of those stakeholders identified in previous step are recognized.

3) Identify Product Market: Target market always plays a vital role in success of any project so here target market is identified to analyse the trends.

10.2 Stage 2

All inputs gathered in stage one is processed for decision making in stage 2.

1) Stakeholder's Weight age: Here stakeholders are assigned weight age based on the priorities and importance of stakeholders with different abilities and requirements.

2) Impact factors related to global software development: Impact factors related to global software development are determined in this stage based on the input of previous stage.

3) Communication parameters: Communication parameters are set based on previous input and any further negotiation is carried out.

10.3 Stage 3

It comprises of requirement weight age.

1) Requirement's Weight age: Requirements are given weight age based on the stakeholder's weight age.

10.4 Stage 4

This is the foremost prioritization step in this framework.

1) Prioritization Process: Requirements are prioritized using predefined criteria of requirement and stakeholder's weight age and according to author any technique discussed in [2] can be utilized.

10.5 Stage 5

Conflicts are always there when multiple stakeholders work together having diverse capabilities and requirements.

1) Negotiation Process: In this stage any conflict raised is resolved.

11. Critical Analysis of Proposed GSD Model

If we critically assign the proposed framework then we see that the weight age is assigned to stakeholders based on the impact factors related on global software development but the criteria of assigning this weight age is not clearly defined. It's confusing whether a numerical analysis would be used or not. Also author suggest utilizing any technique

of requirement prioritization discussed in paper but we cannot use any technique blindly without any result analysis. In stage 3 weight age is assigned to requirements based on the stakeholder's weight age but again no criteria are defined to assign relative weight age to requirements.

12. Proposed Solution to Integrated Model

If we analyse the problems then we can have a solution to identified problems in proposed framework as in stage 3 requirements are assigned weight age based on stakeholder's weight age. In my opinion here at this stage relationship matrix should be used to analyse the association between the requirements and stakeholder's weight age so for this purpose model must include this matrix where relative weight age is assigned to requirements based on the factors discussed in paper to keep track of all the assigned weight age to requirements. A simple matrix involving stakeholders and requirements is depicted in figure 10.

	REQ1	REQ2	REQ..	REQ..	REQ..	REQ n
Stakeholder 1	2	7	...	...	...	...
Stakeholder 2	3	...	...	...	...	...
Stakeholder ..	...	...	4	...	5	...
Stakeholder ..	...	...	...	...	...	...
Stakeholder ..	...	...	...	...	...	...
Stakeholder n	...	...	...	...	...	...

Fig 10 matrix showing relative weight age to requirements based on the relative weight age of each stakeholder

There are different prioritization techniques as discussed in earlier sections with detail analysis in [7][8][9] and [10]. It would be advised to use the technique discussed in [11], proposed by Holly Parsons and Hann, Kecheng Liu by utilizing a matrix approach to prioritize requirements by which stakeholders are ranked in a fixed scale of 1 to 4 using business strategy theorist tool. As global factors are affecting the process and this technique is considering these factors so its best choice to use this technique because in this way ranked stakeholders are sorted by their interests by using matrix. Every stakeholder is assigned an agent working directly with stakeholder to keep track of requirements proposed by the stakeholder to check the duplication and any miscommunication. More detail analysis of this technique is discussed in [11].

13. Conclusions and Suggestions

In this Research different requirement prioritization techniques and strategies are discussed in relation to both traditional software development and software developed in global environment. Main focus of this research was to identify and analyze requirement prioritization techniques suitable for distributed software development and in house local software development. A detailed analysis of ETVX based prioritization model is presented with its limitations and suggested solution which a new technique for requirement prioritization in global software development is also presented with intended modifications.

ETVX was proposed by the author to be a complete package for software development with focus on requirement prioritization in requirement engineering phase but author missed the trick behind the requirement prioritization and I proposed a modified version of this proposed technique which incorporate negotiation loop in requirement prioritization with innovative technique for prioritization in prioritization phase of this model which was missing in original model to accommodate conflict resolution, change management and traceability of requirement in result of changes in requirements. To prioritize requirement, I suggested using HCV method in task section of ETVX model which eliminate categorization and placement steps.

Distributed software development face a lot of challenges but main focus of this research was to introduce an integrated prioritization technique for requirement engineering process carrying out in global environment which already face a lot of challenges and different from traditional in house local software development with the availability of all team members and stakeholders at one place. Integrated prioritization framework has been critically analyzed and it's suggested to include relationship matrix to keep task and relative values to the requirements based on the stakeholder's weight age.

14. Future Work

Further research can be made on ETVX based model of prioritization of requirements. In future my plan is to extend this model further to improve entry, validation and exit criteria to be best suitable for prioritization. Mechanism can be devised for suitable method for stakeholder identification and selection. Further more in future this proposed solution can be extended to be usable for any kind of requirement prioritization whether local or global by integrating this model with techniques suitable for global software development by keeping in view challenges in software development.

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