

Using Essence to Help GSD Teams to Select The Most Appropriate RCM Method for them

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Abstract— In last few decades Global Software Development (GSD) has become an important practice in the Software Industry. Organizations are adopting GSD because they can avail the opportunities of multi-site development like low cost and time, achieving high product quality and access to skillful resources. No doubt there are a lot of benefits of GSD, but this kind of software development is also facing many challenges and Requirement Change Management is one of the most significant challenge they have to face. There are many RCM methods & frameworks for GSD proposed in literature. SEMAT's (Software Engineering Method and Theory) Essence is a standard for working with methods in software engineering, it claims to allow both practitioners and academics to compare, evaluate, tailor, use, adapt, simulate, and measure their methods and practices. We are interested in finding a solution that will help GSD teams to select the most appropriate RCM method for them. We have conducted a study to show how GSD teams can use Essence to find most suitable RCM method or framework for themselves. We showed this by comparing GSD team's competencies against the competencies required for a particular method or framework.

Index Terms— Requirements Change Management Methods, Requirement Change Management Frameworks, Requirement Change Management in Global Software Development, Requirement Change Management Methods in Global Software Development

1 INTRODUCTION

1.1. Requirement Change Management in Global Software Development

Not only the ways through which products are marketed and distributed across the globe are changing but also the processes of their development have been changing too [1].

Global Software Development is the most famous trend to develop software. The most cited benefits are "reduced development cost, leveraging Time-Zone effectiveness, reduced development duration, cross-site modularization of development work, access to large skilled labor pool, innovation and shared best practices, closer proximity to market and customers"[2][3].

According to the U.S. estimation [2] over past 10 years' rate of GSD become 25-fold than the previous one. It has also been predicted that in U.S. one-quarter of software developing organizations are spending for off shore software development. Through GSD client organizations of developing countries have to pay less for software development than if vendor organizations are co-located[4] [2].

Along with its benefits, GSD is also facing many challenges. These include a lot of cultural differences, improper leadership, ad-hoc based development teams as well as lack of proper communication among all stakeholders, teams are scattered across the globe, changes in time zones, inexperienced people and improper requirement change management process[5][6]. Besides many other challenges Requirement Change Management is one of the most important challenge reported in literature that teams have to face in Global Software Development. Requirements are changed throughout the software development life cycle due to several reasons such as business

goals, market demands, software and system requirements change, government rules and regulations, user demands, high level of understandability of customers' needs, enhancement in technology and organizations' business competition [7][8]. Since teams are globally scattered, difference in cultures, time zones and languages cause communication problems. In such a type of development environment, the changes in requirements becomes a challenging activity for GSD teams. Because whenever we try to make change in any requirement it will affect the cost of project as well as the schedule of project and also the quality of final product [6]. Requirements volatility as explained by sNurmuliani et al. [9] is "the tendency of requirements to change over time in response to the evolving needs of customers, stakeholders, organization and work environment".

According to Lai and Ali [10] the main reason that researchers have identified for low success of GSD projects is improper mechanism of RCM problems. Successful development of software projects in GSD depends upon the RCM process.

Requirement Change Management is an activity that is conducted through mutual cooperation. Success of this process is possible only if all the stakeholders work through coordination and effective communication [11][12][13]. If Requirement Change Management process fails it would have bad consequences like increase in cost of software, extended schedules, volatile requirements and unending testing process, as a result the overall project fails and a great loss to business [14],[8],[15],[16], [17],[18],[19].

Recently a study has been done to identify the challenging factors that affect the requirement change management process [6]. One of the important factor authors have identified is "lack of a proper method or practice implementation to exe-

cute the RCM process in GSD successfully". This factor reveals that if GSD teams have a proper method or practice to implement RCM, they can overcome the RCM issues.

Many frameworks, methodologies and processes have been proposed in literature to mitigate this problem but still GSD teams are facing problems to implement RCM. In this paper we have tried to find out a solution through which GSD teams can select that which method is more suitable for them within the available resources. In next sections we have selected a standard that can compare the previous practices. So that it become easy for the development teams to find out that how much their current practice fulfils a standard, and it will help them to execute RCM in GSD successfully.

The remainder of this paper is organized as follows. In Section-II we will discuss the Literature reviewed, in Section-III we will briefly introduce Essence standard, Section-IV presents the method used for this study. Then, in Section-V we will discuss the results of our study, and limitations. Finally, Section-VI offers some conclusions, and directions for future work.

2 MATERIALS & METHODS

2.1 Essence of Software Engineering

Essence is a standard that provides a common ground for all software engineering methods so that it become easy to compare a practice or method that how much it is according to software engineering principles. Essence is method agnostic; it does not have any concern that how a particular software engineering method accomplishes its tasks, it only focuses on the building blocks of different software engineering methods. It is organized into three areas of concerns, i-e, customer, solution and endeavor. It combines all important elements of software engineering and categories them as kernel's alphas, activity spaces and competencies. It also provides a language to define practices so that their usage becomes easy[23].

Essence Kernel has some important features[24], among all of them two features which we form base of our research approach are:

1. It allows its users to evaluate their current practices against a technique neutral control framework
2. Allowing its users to align and compare your on-going work and methods to a common technique neutral framework, and then to complement it with any missing critical practices or process elements.

Above mentioned points claim that Essence can be used as a standard for making comparison or evaluate any practice.

It means that Essence enables its users that they actually do what they claim to do. In our study we will use Essence as a standard, and compare our selected RCM in GSD method/framework with it, so that they become usable for the GSD teams.

So, we have selected Essence as a standard, to find either it is able to help GSD teams to find out that which RCM method/framework is most suitable for a particular GSD organization or not.

3 METHODOLOGY

We have reviewed those papers from literature that include issues of RCM in GSD and provided solution by proposing different methods/frameworks. After critically analyzing related work from literature, we identified our problem area.

We designed a solution that will help GSD teams to select the most suitable RCM Method/Framework by finding out how much effort a method/framework will require from them in a particular Area of Concern.

We essentialized existing RCM methods, frameworks and models so that GSD teams will be able to compare and select most suitable method in their work. Finally, we propose solution as how to compare various methods, frameworks and models once they have been Essentialized.

1. Identify various methods, models and frameworks.
2. Essentialized these various methods up to a level so that they can be compared with each other.
3. We demonstrate how GSD teams can compare these essentialized methods to find most suitable RCM method for themselves.

3.1 Research Question

We have identified the following question from our problem domain after investigating the literature:

RQ1) Can GSD teams select most suitable RCM method for them using Essence?

3.2 Research Approach

The research approach we are going to use is Systematic Approach for Mapping Software Development Methods to the Essence Framework [25]. This approach was previously used to map Nexus Method which is based on SCRUM [25]. As Essence is method agnostic, this reason helps us to apply this approach to find our solution.

According to this approach a method is mapped with concepts of Essence provided in the OMG maintained Essence standard. After that a method will be called as essentialized on the basis of results of mapping.

We will essentialize the selected methods/frameworks up to the level so that teams can identify which method/framework is compatible for their work. This approach uses ontological based concepts and linguistic concepts of Essence Framework for mapping software development concepts with Essence Framework. This approach defines six steps of mapping that are shown in Fig 3.1

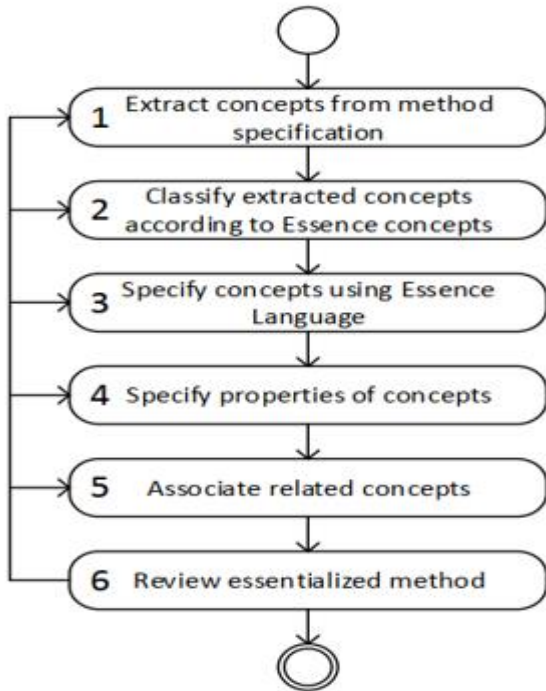


Fig 3.1 Top Level View of the Systematic Mapping Approach [25]

From Fig 3.1 it is obvious that this approach works by following some steps. First of all, concepts are extracted from the selected method/framework by performing verb-noun analysis. Nouns extracted at this phase will result in a list of work products, alphas and sub alphas. While the verbs mostly refer to the activities. In the next step these extracted verbs and nouns are mapped with the Essence concepts and are classified as Essence concepts in textual form. In third step the essence language is used to specify each concept. For this purpose, the author has used a tool i-e, Workbench. In next step properties of each concept are specified with the help of Essence Language. After that the relationship among the identified concepts is analyzed according to the semantics of relationships provided in the predefined Essence Language. In the last step quality of essentialization process for the particular method is reviewed. If it is not satisfactory than the previous steps are repeated [25].

In our research approach we will implement the first two step of above-mentioned systematic mapping approach. After which we will map each mapped concept with the particular area of concern. Although this step is not the part of systematic mapping approach [25], but we will perform it to make our work more understandable for GSD Teams.

After performing this step, we will be able to find out that how much a method/framework is performing in a particular area of concern. We will record this result in the form of bar chart.

This step will improve clarity of concepts and understandability for the GSD teams to select a method.

3.3 Systematic Mapping Process

We are going to apply Systematic Mapping Approach [25] for all the selected methods/frameworks. We will implement it up to two levels of Systematic Mapping Approach. The first step will extract concepts from each of our selected approaches, on the basis of verb-noun analysis and categories each concept with respect to concept category. As there are many types of verbs and nouns used in each method/framework. Some of them represent any activity, some represent artifacts, work products, operations on artifacts etc. Our first step will help us to extract all such concepts and relating them to their respective category. In second step we tried to map each extracted concept to the Essence Concepts. After completion of this step, we become able to know that which concept belongs to alpha, activity space and competency of which area of concern.

3.4 Relating Mapped Concepts to the Particular Area of Concern

Now we will apply our proposed step for which we have already discussed in previous section. We will relate each mapped concept with its particular Area of Concern. As Essence is organized into three major areas of concern i-e,

- i). Customer Area of Concern
- ii). Solution Area of Concern
- iii). Endeavor Area of Concern

Results are recorded in the form of tables that are represented in Tables 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6.

3.4.1 Area of Concern Mapping for Framework-1: A Propose Framework for Requirement Change Management in Global Software Development [21]

TABLE 3.1 Mapping of Essence Concepts with Area of Concern for Framework-1

| Sr. No | Extracted Concept | Concept Category | Essence Concept | Area of Concern |
|--------|--------------------------|------------------|-------------------|-----------------|
| 1. | Client | Stakeholder | Stakeholder | Customer |
| 2. | Distributed Site | Team | Team Sub Alpha | Endeavor |
| 3. | Change Request | Requirement | Requirement Alpha | Solution |
| 4. | Change Initiation | Event | Activity Space | Solution |
| 5. | Change Evaluation | Activity | Activity Space | Solution |
| 6. | Change Decision | Activity | Activity Space | Solution |
| 7. | Change Implementation | Activity | Activity Space | Solution |
| 8. | Change Moderator | Team Member | Pattern [Role] | Endeavor |
| 9. | Central Repository | Artifact | Work Product | Solution |
| 10. | Communication with Sites | Activity | Activity Space | Endeavour |

3.4.2 Area of Concern Mapping for Framework-2: Requirement Change Management in GSD using Ontology [16]

TABLE 3.2 Mapping of Essence Concepts with Area of Concern for Framework-2

| Sr. No. | Extracted Concept | Concept Category | Essence Concepts | Area of Concern |
|---------|-----------------------|------------------|-------------------|-----------------|
| 1. | GSD Project | Opportunity | Opportunity Alpha | Customer |
| 2. | User | Stakeholder | Stakeholder Alpha | Customer |
| 3. | Site | Team | Sub Alpha of Team | Endeavor |
| 4. | Change request | Requirement | Requirement Alpha | Solution |
| 5. | Project manager | Team Member | Pattern [Role] | Endeavor |
| 6. | Change control board | Team | Sub Alpha of Team | Endeavor |
| 7. | Change Implementer | Team Member | Pattern [Role] | Endeavor |
| 8. | Inspection | Event | Activity Space | Solution |
| 9. | Update change | Activity | Activity Space | Solution |
| 10. | Decision Making | Event | Activity Space | Solution |
| 11. | Change implementation | Activity | Activity Space | Solution |
| 12. | Review report | Artifact | Work product | Solution |
| 13. | Implemented change | Artifact | Work product | Solution |
| 14. | Change request form | Artifact | Work product | Customer |

3.4.3 Area of Concern Mapping for Method-1: A Requirement Change Management Method for Global Software Development [10]

TABLE 3.3 Mapping of Essence Concepts with Area of Concern for Method-1

| Sr. No. | Extracted Concept | Concept Category | Essence Concept | Area of Concern |
|---------|--|--------------------------|-------------------|-----------------|
| 1. | Requirements Change Management | Operation on an Artifact | Activity Space | Solution |
| 2. | Request for changes in requirements | Requirement | Requirement Alpha | Solution |
| 3. | Identification of development teams & related requirements | Work | Work Alpha | Endeavor |
| 4. | Change Understanding | Activity | Activity Space | Solution |
| 5. | Contact development teams related to requirements | Activity | Activity space | Endeavour |
| 6. | Change Analysis | Activity | Activity Space | Solution |
| 7. | Discuss change analysis outcomes | Activity | Activity Space | Solution |
| 8. | Change Finalization | Activity | Activity Space | Solution |
| 9. | Record Change Outcome | Activity | Activity Space | Solution |
| 10. | Change Notification | Event | Activity Space | Solution |

3.4.4 Area of Concern Mapping for Framework-3: An Improved Framework for Requirement Change Management Method in Global Software Development [20]

TABLE 3.4 Mapping of Essence Concepts with Area of Concern for Framework-3

| Sr. No. | Extracted Concept | Concept Category | Essence Concept | Area of Concern |
|---------|--|-----------------------|----------------------|-----------------|
| 1. | Change Request | Requirement | Requirement Alpha | Solution |
| 2. | Change Initiation | Event | Activity Space | Solution |
| 3. | Client | Stakeholder | Stakeholder | Customer |
| 4. | Distributed Sites | Team | Team Alpha | Endeavor |
| 5. | Change Manager | Team member | Pattern [Role] | Endeavor |
| 6. | Change Control Board | Team Members | Team Sub Alpha | Endeavor |
| 7. | Process Change Request | Operation on artifact | Activity Space | Solution |
| 8. | Change Evaluation Process | Activity | Activity Space | Solution |
| 9. | Requirement Change Management Data Base | Artifact | Work Product | Solution |
| 10. | Change Evaluation | Activity | Activity Space | Solution |
| 11. | Threshold Time for Change Control Board | Measuring Metrics | No Match Found | No Match Found |
| 12. | Voting on Evaluation Results | Activity | Activity Space | Endeavour |
| 13. | Requirements Repository | Artifact | Work Product | Solution |
| 14. | New Threshold | Measuring Metrics | No Match Found | No Match Found |
| 15. | Process Change Control Board Feedback | Operation on Artifact | Way of Working Alpha | Endeavor |
| 16. | Change Control Board Decision | Artifact | Work Product | Solution |
| 17. | Change Implement | Artifact | Work Product | Solution |
| 18. | Update Requirement Change Management Data Base | Operation on artifact | Activity Space | Solution |
| 19. | Inform Sites | Activity | Activity Space | Endeavour |
| 20. | Change Request Form | Artifact | Work Product | Solution |

3.4.5 Area of Concern Mapping for Method-2: A Method of Requirement Change Management for Global Software Development [8]

TABLE 3.5 Mapping of Essence Concepts with Area of Concern for Method-2

| Sr. No. | Extracted Concept | Concept Category | Essence Concepts | Area of Concern |
|---------|---|------------------|-------------------|-----------------|
| 1. | Change Understanding at different GSD sites | Activity | Activity pace | Customer |
| 2. | Understanding existing requirements | Activity | Activity pace | Solution |
| 3. | Understanding changes in requirements | Activity | Activity Space | Solution |
| 4. | Estimating extent of change | Value Change | Opportunity Alpha | Customer |

| Sr. No. | Extracted Concept | Concept Category | Essence Concepts | Area of Concern |
|---------|---|--------------------------|-------------------|-----------------|
| 5. | Communicate details about Changes in requirements | Activity | Activity Space | Endeavour |
| 6. | Change analysis at different GSD sites | Activity | Activity Space | Customer |
| 7. | Computation of measures at the main GSD sites | Activity | Activity Space | Customer |
| 8. | Modules affected by changes in software requirements | No Match Found | No Match Found | No Match Found |
| 9. | Involvement of GSD sites during change management | Team Involvement | Team Alpha | Endeavor |
| 10. | Involvement of cultural setups during change management | Stakeholders involvement | Activity Space | Customer |
| 11. | Change Analysis | Activity | Activity Space | Customer |
| 12. | Computation of measures b/w different GSD sites | Activity | Activity Space | Solution |
| 13. | Modules affected by changes in software requirements | No Match Found | No Match Found | No Match Found |
| 14. | Involvement of GSD sites during change management | Team involvement | Team Alpha | Endeavor |
| 15. | Involvement of cultural setups during change management | Stakeholders involvement | Stakeholder Alpha | Customer |
| 16. | Change finalization b/w different GSD sites | Team involvement | Team Alpha | Endeavor |
| 17. | Analyze change effect on overall project | Activity | Activity Space | Solution |
| 18. | Analyze change effect for different GSD teams | Team involvement | Team Alpha | Endeavor |
| 19. | Compare change effects | No Match Found | No Match Found | No Match Found |
| 20. | Decision made on change finalization | Activity | Activity Space | Solution |

3.4.6 Area of Concern Mapping for Method-3: A Domain Ontology for Software Requirements Change Management in Global Software Development Environment [22]

TABLE 3.6 Mapping of Essence Concepts with Area of Concern for Method-3

| Sr. No. | Extracted Concept | Concept Category | Essence Concept | Area of Concern |
|---------|----------------------------|---------------------------|-------------------|-----------------|
| 1. | End User | External Change Initiator | Stakeholder Alpha | Customer |
| 2. | Customer | External Change Initiator | Stakeholder Alpha | Customer |
| 3. | Team Member | Internal Change Initiator | Pattern [Role] | Endeavor |
| 4. | Quality Assurance Team | Team | Team Sub Alpha | Endeavor |
| 5. | Change Initiator | Team member | Pattern [Role] | Endeavor |
| 6. | Change Control Board | Team | Team Sub Alpha | Endeavor |
| 7. | Change Builder | Team member | Pattern [Role] | Endeavor |
| 8. | Change Manager | Team member | Pattern [Role] | Endeavor |
| 9. | Change Verification Report | Artifact | Work Product | Solution |
| 10. | Change Verification | Activities | Activity Space | Solution |
| 11. | Change Validation | Activities | Activity Space | Solution |
| 12. | Change Schedule | Activity | Activity Space | Solution |

| | | | | |
|----|----------------------|--------------------------|----------------|----------|
| 13 | Change Schedule Plan | Artifact | Work product | Solution |
| 14 | Change Manager | Team member | Pattern [Role] | Endeavor |
| 15 | Modification | Operation on an Artifact | Activity | Solution |
| 16 | Addition | Operation on an Artifact | Activity | Solution |
| 17 | Deletion | Operation on an Artifact | Activity | Solution |

4 RESULTS & DISCUSSIONS

4.1 Results

Final results of each method/framework are collectively recorded in the form of a bar chart to make clear analysis of final results. Figure 5.1, shows the bar chart in which different colors of bars represent a specific area of concern. X-axis consists of Areas of Concerns for all the selected six practices while the Y-axis represents the numbers of concepts of each Area of Concern. Blue color represents Customer Area of Concern, orange is for Solution Area of Concern and Gray is for Endeavor Area of Concern, while yellow color represents how much concepts are miss-matched with the Essence concepts. If a practice completely matches the standard it does not have yellow bar. It is obvious from the graph that how much a practice performs in a particular area of concern that we have mentioned in our proposed methodology.

From the graphical representation in Fig 4.1, we found that:

There is only one concept in Framework-1 that is mapped across Customer Area of Concern, six concepts are mapped across solution area of concern and three concepts that are successfully mapped across Endeavor Area of Concern.

We found three concepts in Framework-2 targets that are mapped across Customer Area of Concern, seven concepts across Solution Area of Concern and four concepts across Endeavor Area of Concern.

In Method-1 there is no concept that will be mapped across customer area of concern, eight concepts are mapped across Solution Area of Concern and two concepts mapped successfully across Endeavor Area of Concern.

Framework-3 has only one concept that is compatible with Customer Area of Concern, eleven concepts we found that are mapped successfully across Solution Area of Concern and six concepts are mapped across Endeavor Area of Concern. Two of its concepts does not match with any Essence Concept.

There are seven concepts we found in Method-2 that are compatible with Customer Area of Concern, five concepts match with Solution Area of Concern and also five concepts match with Endeavor Area of Concern.

In Method-3 we found two concepts that are mapped across Customer Area of Concern, eight concepts across Solution Area of Concern and seven concepts matches with Endeavor Area of Concern.

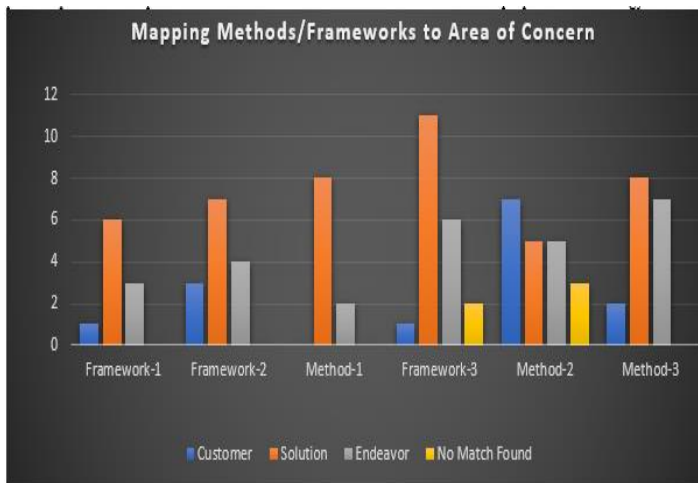


Fig 4.1 Mapping of Frameworks, Model & Methods with Area of Concern

4.2 DISCUSSIONS

On the basis of these results a GSD team can come to know that how much these selected methods/frameworks are performing in certain Area of Concern according to Essence Standard. GSD teams can easily decide for themselves that according to their available resources which type of method/framework is suitable for them. As we know that each developing organization depends upon its resources to complete a work successfully. Through our work a development team should be able to know that

- Their available resources are compatible to which method, model or framework and how much effort they will require for a certain method/framework to adapt it.
- How much alphas, activity spaces and competencies they must have for a certain area of concern to handle the issue of RCM in GSD.

The overall findings from figure. 4.1 shows that:

If a team is working on RCM by using Framework-1 it should have more competencies, alphas and activity spaces in Solution Area of Concern than in Endeavour and Customer Area of Concern. A GSD team will need more effort in Solution Area of Concern as compared to Endeavor and Customer Area of Concern if it adapts Framwork-1.

Framework-2 requires larger level of alphas, competencies and activity spaces in Endeavor Area of Concern as compared to these elements in Customer and Solution Area of Concern. If a GSD team adapts this Model it should requires more effort in Endeavor Area of concern than in Customer and Solution Area of Concern.

Method-1 can be workable if a GSD team do not have sufficient competencies, alphas or activity spaces in Customer Area of Concern. It needs maximum effort of a GSD team in Solution Area of Concern and lower than that in Endeavor Area of Concern.

Framework-3 requires the highest level of competencies, alphas and activity spaces in Solution Area of Concern among all the others selected methods/frameworks. If a GSD team implements Framework-2 for RCM process it needs maximum effort in Solution Area of Concern, lower than that in Endeavor Area of Concern and a minimum effort in Customer Area of Concern.

Method-2 requires more Essence elements in Customer Area of Concern than Solution or Endeavor Area of Concern. It requires maximum effort of a GSD team in Customer Area of Concern, lower than that in Solution and Endeavor Area of Concern to implement Method-2 for RCM process.

Method-3 requires higher level of alphas, activity spaces and competencies in Solution Area of Concern than other two Areas of Concerns. A team requires more effort in Solution Area of Concern, less than that in Endeavor Area of Concern and least level of effort in Customer Area of Concern for Method-3 implementation.

5 CONCLUSION & FUTURE WORK

We have achieved our research objective successfully. In research approach we have proposed that we will identify some methods/frameworks for RCM in GSD and Essentialize them up to the level so that different GSD can select the appropriate RCM method for them. So, we have Essentialized each method/framework up to a certain level, and maintained their information in tabular form. The two steps that we have performed helped us to extract the important concepts from methods/ frameworks specifications and we successfully mapped each concept to the Essence Standard.

To help GSD teams to select the most appropriate RCM approach for them we have demonstrated that how much each method/framework performs in a certain area of concern. With the help of a bar-chart we demonstrated our results of this step. From the bar-chart as shown in Figure.5.1 a GSD team can easily know that how much effort they require to successfully implement RCM process.

Our final results will help GSD teams to select the most appropriate method/framework for them according to their available resources, so that they implement RCM process successfully.

In future we will completely Essentialize the methods/frameworks of RCM in GSD by applying the remaining steps of Systematic Mapping Approach for Software Engineering Methods. So that it will provide detailed information to the GSD teams to execute RCM process smoothly. Our next step will increase more understandability and help GSD teams to handle RCM issues.

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