An Efficient Evaluation of Requirements Engineering Maturity Measurement Framework For Medium and Small Scale Software Companies

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ABSTRACT
Requirements Engineering (RE) problems are widely acknowledged as having a major impact on the effectiveness of the software development process. Sommerville et al. have developed a requirements maturity model. However, research has shown that the measurement process within Sommerville’s model is ambiguous, and implementation of his requirements maturity model leads to confusion. Hence, Mahmood Niazi, Karl Cox, June Verner proposed a new RE maturity measurement framework (REMMF) based on Sommerville’s model. The objective of research is to efficiently evaluate the RE maturity measurement framework (REMMF) for RE process maturity assessment. We present a tool support in order to perform calculations and to generate different assessment reports; we also present the assessment of good practice guidelines and maturity assessment results for different companies. Our conclusion is that the requirements engineering maturity measurement framework is useful in supporting maturity assessment, identifying requirements engineering process maturity.

BACKGROUND:
The RE process has a huge impact on the effectiveness of the software development process [5]. When RE processes are ad hoc, poorly defined or poorly executed, the end product is typically unsatisfactory [15]. Sommerville et al. [12], [13], [14] developed a maturity model derived from existing standards. Their maturity model has three maturity levels: Level 1—Initial, Level 2—Repeatable and Level 3—Defined. The model can be used to assess a current RE process and provides a template for RE practice assessment. In this model, Sommerville et al. propose a number of practices that lead to RE process improvement and that ultimately should lead to business benefits [13]. Although all the practices of Sommerville et al.’s maturity model are very well defined, the measurement process designed for these practices was very confused and could lead organizations to undesirable results. This is caused by an ambiguous measurement process without a strategic and systematic approach being used to decide different scores for various practices. The practitioners interviewed [9],[10]nted a more formal and structured measurement process in order to better assess the maturity of their RE processes. Sommerville et al. have noted: “this assessment scheme is not a precise instrument and is not intended for formal accreditation” [12]. As research has shown that effective RE practices provide multiple benefits including help in keeping delivery times and product quality under control [12],[16], it is very important for organisations to systematically discover which RE practices are weak or strong. Sommerville et al.’s model does not provide this detailed practice-based assessment except for the provision of an indication of the RE maturity levels, i.e. Level 1, Level 2 etc., which lack much useful information. Their model does not provide any indicators to measure each RE practice and it also evaluates RE process using a single dimension [8].

REMMF:
RE maturity measurement framework (REMMF) designed to be used with Sommerville et al.’s model in order to effectively measure the maturity of the RE process. This measurement framework can also be used to evaluate the strength or otherwise of RE practices. The structure of REMMF is shown in Fig. 1.
The 66 good practices designed by Sommerville et al. can be divided into eight categories: requirements documents, requirements elicitation, requirements analysis and negotiation, describing requirements, system modeling, requirements validation, requirements management and requirements for critical systems. These categories are ‘requirements process category’. The requirements process category maturity indicates how mature the requirements process is [14]. These requirements process categories contain different good practices designed for RE processes [12],[14]. For each good practice we have designed a process, in order to effectively measure its maturity. The following steps are used in REMMF [1], [3], [11] to measure the maturity of RE processes.

**Step 1:** For each practice, a key participant who is involved in the RE process assessment calculates a 3-dimensional score for each RE practice using the tailored Table 1.

**Step 2:** The 3-dimensional scores for each practice are added together, divided by 3 and rounded up. A score for each practice is placed in the evaluation sheet.

**Step 3:** This procedure is repeated for each practice. The score for each practice is then summed then an average is used to gain an overall score for each ‘requirements process category’.

**Step 4:** A score of 7 or higher for each ‘requirements process category’ indicates that a specific category maturity has been successfully achieved [3],[11]. A category maturity a score that falls below seven is considered a weakness [3],[11].

**Step 5:** It is possible that some practices may not be appropriate for an organisation and need never be implemented. For such practices a ‘Not applicable’ (NA) option is selected. This NA practice should be ignored when calculating the average score of a ‘requirements process category’. At the end of this measurement process it will be very clear to an organisation which requirements process categories are weak and need further consideration.

### EVALUATION OF REMMF FOR SMALL AND MEDIUM SCALE INDUSTRIES, VIA CASE STUDY:

The case study method is used because this is a powerful evaluation tool and can provide useful real world information [17]. A case study also provides valuable insights for problem solving, evaluation and strategy [2]. Since REMMF is applicable to a real software industry environment, the case study research method is applicable to a real software industry environment, the case study research method is believed to be an appropriate method for efficient evaluation. A real life case study is necessary because it can show:

- Whether REMMF is a suitable for use in small and medium scale industries.
- What are the Areas where REMMF requires improvement?
- What is the practicality of REMMF?

We have efficiently evaluated REMMF, proposed by the Mahmood Niazi, Karl Cox, June Verner, of different small and medium scale scale software companies located at Lucknow city in India. Mahmood Niazi, Karl Cox, June Verner, did not provide any software tool support for the assessment reports with in Requirements Engineering Maturity Measurement Frame work. We proposed a software tool support that can perform calculations and can generate different assessment reports. The main purpose of designing software tool support with in Requirements Engineering Maturity Measurement Framework work was to develop a better way to assist practitioners in efficient measuring the Requirements Engineering process maturity of small and medium scale companies. We have assessed the maturity levels of different companies located in Lucknow city in India. The companies were selected so that they represent different application areas, sizes, ages. Thus the assessment gives a general overview of different kind of companies and their attitude towards requirements engineering. Ether software company was five year old, Sun Infotech solution was 4 years old, Laitkor info solution private limited was 7 years old, and Insight solution was 9 years old, out of four companies only two companies were usage configuration management tools, all the four companies were usage testing tools, and one company were usage testing tools.

### IMPLEMENTATION OF R.E.M.M.F.:

We measure the capability of requirement documents process category, requirements elicitation process category, requirements analysis and negotiations process category, describing requirements process category, system modeling process category, requirement validation process category, requirement management process category, requirement for critical system process category, for all the four companies located in Lucknow city India. We proposed a software tool for the Requirements Engineering Maturity Measurement Framework (REMMF) as shown in Fig. 3.
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Our software tool efficiently assess the requirements engineering process maturity. To assess we select a Requirements Engineering process category, as shown in Fig. 4.

Then we select a good practice guideline of the selected requirements engineering process category, for the assessment as shown in fig 5.

And score a good practice guideline of selected requirements engineering process category as shown in fig. 7.
We score each good practice guidelines of the requirements engineering process category for all the three dimensions, approach dimension, deployment dimension, and result dimension, and we score the three dimension overall score of each good practice guideline of the requirements engineering process category. If the three dimension overall score of good practice guideline is more than seven then the good practice guideline is strong otherwise the good practice guideline is weak. In the same way we assess all the good practice guidelines of all the requirements engineering process category and assess the requirements engineering process maturity of an organization.

LESSON LEARNED

Lesson learned are summarized as follows:

- Requirements Engineering Maturity Measurement Framework (REMMF) can also efficiently assess the requirements engineering process in small and medium scale industries in India.
- REMMF, efficiently evaluate the three-dimensional approach; this three-dimensional approaches were evaluated for each requirements engineering practice, which provides an efficient way where management commitment, magnitude of deployment and result of deployment are evaluated.
- REMMF was useful in identifying weak and strong requirements engineering process categories as well as requirements engineering practices for small and medium scale companies.
- REMMF tool support is unambiguous, easy to use and very effective general approach for small and medium scale companies in India.
- REMMF components are easy to understand and easy to implement in an organization.

CONCLUSION AND FUTURE SCOPE

In this paper we efficiently evaluated generalize approach of REMMF to assess the requirement engineering processes for small and medium scale companies in Indian context. Our conclusion is that REMMF tool support is better way to assist the practitioners, in evaluating requirements engineering processes of small and medium scale companies. The result of the four different companies showed that REMMF is useful in the real environment. Our future work is to evaluate the effectiveness of REMMF in the domain of requirement engineering process improvement.

APPENDIX: A

<table>
<thead>
<tr>
<th>Score</th>
<th>Approach</th>
<th>Weak (2)</th>
<th>Fair (4)</th>
<th>Marginally qualified (6)</th>
<th>Qualified (8)</th>
<th>Outstanding (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor (0)</td>
<td>No management recognition of need, No organizational ability, No</td>
<td>Management begins to recognize need, Support items for the practice start</td>
<td>Wide but not complete commitment by management Road map for practice</td>
<td>Some management commitment, some management becomes proactive Practice implementation</td>
<td>Total management commitment, Majority of management is proactive, Practice</td>
<td>Management provides zealous leadership and commitment Organizational excellence in</td>
</tr>
<tr>
<td></td>
<td>organizational commitment, Practice not evident, Higher management is</td>
<td>start to be created, A few parts of organization are able to implement</td>
<td>implementation defined Several supporting items for the practice in</td>
<td>well under way across parts of the organization, Supporting items in place, Management</td>
<td>established as an integral part of the process, Supporting items encourage and</td>
<td>the practice recognized even outside the organization.</td>
</tr>
<tr>
<td></td>
<td>not aware of investment required and long term benefits of this practice</td>
<td>the practice Management begins to aware of investment required and</td>
<td>in place, Management has some awareness of investment required and long</td>
<td>management has wide but not complete awareness of investment required and long term</td>
<td>facilitate the use of practice, A mechanism has been established to use and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>long term benefits of this practice</td>
<td>term benefits of this practice</td>
<td>term benefits of this practice.</td>
<td>monitor this practice on continuing basis, Management has wide and complete</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>awareness of investment required and long term benefits of this practice.</td>
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</tbody>
</table>

Score | Deployment |
--- | -----------|
Poor (0) | No part of the organization uses the practice, No part of the organization shows interest |
Weak (2) | Fragmented use, Inconsistent use, Deployed in some parts of the organization, Limited to monitoring/verification of use |
Fair (4) | Less fragmented use, Some consistency in use, Deployed in some major parts of the organization Monitoring/verification of use for several parts of the organization, No |
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<table>
<thead>
<tr>
<th>Score</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor (0)</td>
<td>Ineffective</td>
</tr>
<tr>
<td>Weak (2)</td>
<td>Spotty results, Inconsistent results, Some evidence of effectiveness for some parts of the organization.</td>
</tr>
<tr>
<td>Fair (4)</td>
<td>Consistent and positive results for several parts of the organization, Inconsistent results for other parts of the organization.</td>
</tr>
<tr>
<td>Marginally qualified (6)</td>
<td>Positive measurable results in most parts of the organization, Consistently positive results over time across many parts of the organization.</td>
</tr>
<tr>
<td>Qualified (8)</td>
<td>Positive measurable results in almost all parts of the organization, Consistently positive results over time across almost all parts of the organization.</td>
</tr>
<tr>
<td>Outstanding (10)</td>
<td>Requirements exceeded. Consistently world, class results, Counsel sought by others.</td>
</tr>
</tbody>
</table>

Table 1.

<table>
<thead>
<tr>
<th>Requirements Engineering process category</th>
<th>Sun Infotech</th>
<th>Ether Software</th>
<th>Laitkor info solution</th>
<th>Insight solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement Document category</td>
<td>1.5</td>
<td>2.5</td>
<td>2.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Requirements Elicitation</td>
<td>1.8</td>
<td>2.1</td>
<td>2.4</td>
<td>7.2</td>
</tr>
<tr>
<td>Requirements Analysis and Negotiation</td>
<td>2.1</td>
<td>2.5</td>
<td>3.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Describing Requirements</td>
<td>3</td>
<td>3.2</td>
<td>4.4</td>
<td>7.8</td>
</tr>
<tr>
<td>System Modeling</td>
<td>1</td>
<td>2</td>
<td>4.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Requirements Validation</td>
<td>1</td>
<td>1</td>
<td>2.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Requirements Management</td>
<td>0</td>
<td>2.2</td>
<td>3.7</td>
<td>7</td>
</tr>
<tr>
<td>Requirements Critical Systems</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2.

REFERENCES

APPENDIX: B
The three dimension overall score Requirements Engineering process category.


