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A CMMI-Based Method for Software Development Process Assessment: Applying CMMI Process in Saudi Arabia

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Abstract

CMMI is globally accepted as a software development standard. It provides guidelines and practices to enhance product quality. This study examined the CMMI practices adoption in Saudi Arabian software firms; we found that the awareness and adoption of CMMI practices are low. Thus, it is difficult to enhance the quality of the software product. This study collected data through interviews and observations of project documentation and the process of software development. We found that software development firms in Saudi Arabian do not have sufficient awareness and understanding of CMMI, although they are aware of the CMMI framework and use a form of CMMI programs to develop software products. To overcome this problem, it is necessary to adopt the CMMI framework that provides software development firms with the guidelines and practices required to improve the quality of software products. The example firms that utilization a type of CMMI programs detailed an improvement in software item quality. These discoveries affirm the significance of the CMMI system as a method for delivering better software items, which can improve the probability of software organizations dominating the race in creating qualified items expected by their stakeholders. The cycle that has effectively great is in the process territory Supplier Agreement Management (SAM) and most of the cycles nearby REQM (Requirements Management) and PP (Project Planning). Software development measures should be improved in the process area with the need for PMC (Project Monitoring and Control), MA (Measurement and Analysis), PPQA (Process and Product Quality Assurance), then CM (Configuration Management).

Disciplinary: Computer Science and Engineering (Software Engineering).

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1 Introduction

The improved quality of the software becomes an essential need since the software development continues to evolve of business processes changes, the feature additions, in addition to the advances of application of new and complex technologies. The quality of the software is examined by the quality of the maintenance process [1]. The process of making software is a major factor that affects the success or failure of the development process of software [2]. Software development processes constantly struggle to improve the software product quality and delivery, software developers' productivity, less time and cost of software enhances business growth and improve customer satisfaction. However, usually, there are still software projects that are not in accordance with the expectations of the software firms and the stakeholders. Such as a delay of implementation as well as frequent and unmanaged requirements changes most of the time, therefore a negative effect in production costs and hence software firms' revenue [1]. Capability Maturity Model Integration (CMMI), originated by Software Engineering Institute (SEI), is one of the guides that provides software developers with the guidelines to expand the expertise of software organizations to produce high-quality software products.

However, the CMMI activity was introduced forty years before but its awareness and usage area still lo1 [10]. A few researchers contend that the low selection is because of these activities being expensive, tedious, problematic, and difficult to use. [11, 12, 13], it consumes major firms' resources like human and financial resources. A few studies and analysts have expressed the advantages of CMMI, which incorporate improved software system/product quality, improved profitability of engineers, low-cost process duration and the cost, upgraded business development, and improved consumer satisfaction [14, 15]. Hence, in view of these advantages, software firms are urged to apply SPI projects to deliver more reliable and robust software products as well as give business value [16]. These conditions can improve the probability of winning worldwide agreements [17,18]. Consequently, there is restricted research on creating approaches to successfully carry out CMMI initiatives in Saudi Arabian software development industries. Moreover, in this study, we evaluate the advantages of CMMI activities in Saudi Arabia software improvement firms. Consequently, the normal output of this investigation is to offer experiences to software improvement professionals in Saudi Arabia in regard to the condition of their CMMI awareness, advantage, and use. Such experiences may incite potential research and empower further conversation in Saudi Arabia on the selection of CMMI to turn out to be more serious in the product improvement industry.

2 Literature Study

Software industries should show their product development measure is characterized, overseen, oversaw, and equipped for nonstop improvement through execution measures and criticism, all together HIS archive is a layout for Word (doc, Docx) forms. On the off chance that you are perusing a paper form of this report, so you can utilize it to set up your composition. At the point when someone opens a template.docx, choose "Page Layout" from the "View" menu in the menu bar (View | Page Layout), which permits you to look at the footnotes. At that point type over segments of template.docx or reorder from a new archive and afterward use markup styles. The draw-down style menu is at the left of the Formatting Toolbar at the highest point of your Word window (for instance, the style now in the archive is "Text"). Feature a part that you need to assign with a specific style, at that point select the fitting name on the style menu. The style may change your text styles and line dividing. Try not to change the text dimensions or line dividing to crush more content into a set number of pages. Use italics for accentuation; do not underline. To embed pictures in Word, position the cursor at the inclusion point and either use Insert | Picture | From File or duplicate the picture to the Windows clipboard and afterward Edit | Paste Special | Picture (with "Buoy over text "to upgrade the probability of delivering top-notch programming items, consequently, improve their intensity in the worldwide market. Hence, the product improvement interaction ought to be able and full-grown [14, 18, 19, 20, 21, 22, 23] and afterward surveyed by software industries followed by building up execution intend to accomplish higher cycle development [24].

However, since these programs are costly and time-consuming, many managers are hesitant to set out on them [11]. The most assessment reference framework model of established practices used to assess a software firm's process maturity is the CMMI [19, 25], which can decrease the dependence on a single commitment for quality outcomes [16]. This model has the organized portrayal with five levels that manage software firms in propelling their cycle development beginning with a specially structured interaction until accomplishing a trained and develop formative interaction [26].

CMMI model depends on Process Area (PA), Goal, and Practice. The objective has two sections (1) Specific Goals (SG) and (2) Generic Goal (GG). The practice has two sorts: in particular, Specific Practices (SP) and Generic Practice (GP). SG is a progression of activities or objectives of the cycle territory. SP is the means that are utilized to accomplish objectives. The satisfaction of the SG on the PA mirrors the development level accomplished by the industry [1]. For effective software development, CMMI has recognized 22 cycles that are treated inside the organized stages. The representation of stages treats the product as far as development levels that range from Level 1 through Level 5, see Figure 1. Each interaction area has objectives that must be fulfilled to accomplish certain ability levels for that cycle. There are two sorts of Goals, Specific Goals and Generic Goals. Specific Goals explore certain criteria that must satisfy the specific process area. Generic Goals depict the attributes to systematize the cycles that implement a process area [1].

Level 1 is "initial" because there are no settled practices to control the formative cycle. In Level 2, there are recommended project management adopt. Level 3 "defined", shows more extensive organizational interaction the management rehearses, for example, risk management and organizational training. Level 4 "managed", evaluate how the practices are installed utilizing set up execution measures. Level 5 "optimizing" indicates that the firm is practicing continuous improvement in its software activities. It is broadly stated that in the IS a group that product improvement organizations should be qualified at Level 2 or more to be accessed worldwide competitors [27].

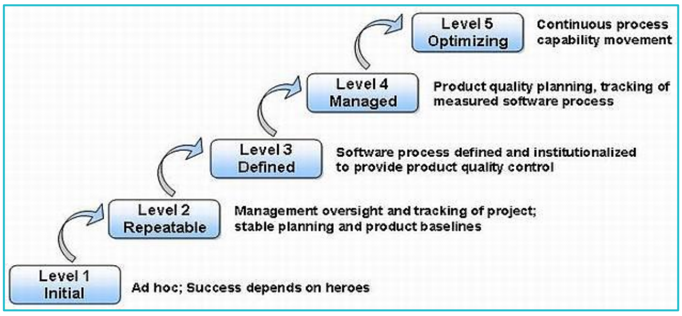

Figure 1: The CMMI Stage representation.

Adjacent to CMMI, there are a few other related models that incorporate the International Organization for Standardization (ISO), individual process of the software, group software interaction, and bootstrap techniques [21, 22]. these models help firms in accomplishing their expected advantages of more reliable software, improved consumer loyalty, better asset usage, and improved business reputation [28, 29].

3 Methodology

This study is based on an online survey method to collect data from Information System professionals in software development firms (i.e., I.T. managers, project managers, programmers, designers, Web developers) throughout Saudi Arabian firms during March 2020. The data obtained was possible respondent names, positions, and email addresses, the email is connected to a link that helps to get the survey instrument. Email invitations were sent to participate in the online survey to fifty-nine software firms (20 governmental organizations and 19 private companies).

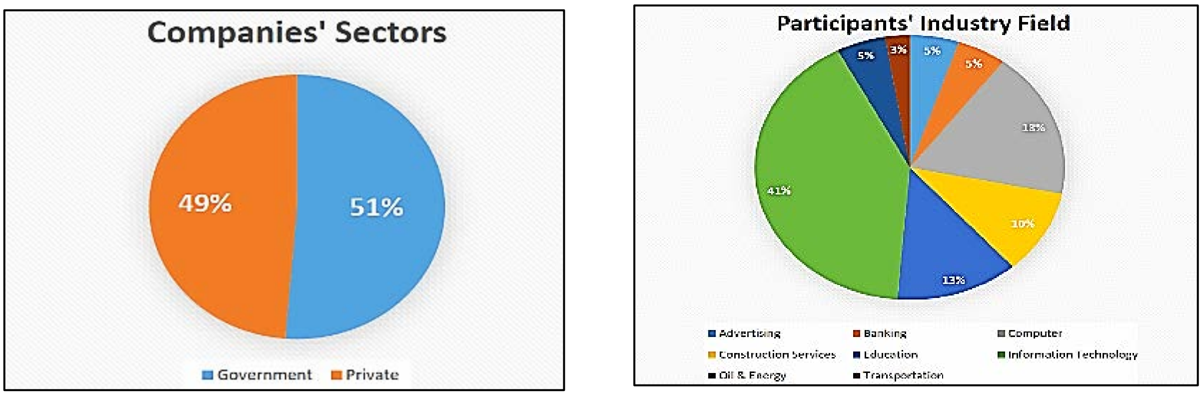

Figure 2: Profile of respondents

Our Hypothesis is "Saudi software companies and government agencies satisfy CMMI level 2". The component of the assessment of the investigation was Information System projects, and people were approached to cover the adoption, awareness, and advantages of utilizing CMMI programs in their firms for the software development and supply of software products. A five-point Likert-scale was applied for questions that were attached as (I do not Know - Not Done - Done partially - done by group Effort - Done with Pre-set Plan - Done with a pre-set Plan & Internal Standard Documents). In Figure 2, an overall of 59 responses was accumulated and analyzed. Most of the participants (59%) belong to the IT departments and software companies, while the other industry fields have 41%, distributed in the activities of advertising, banks, and oil and energy companies (5%), the education organizations (13%), whereas the transportation (3%).

In Figure 3, most of the participants were the IT manager (20%), while (15%) of the participants were project managers, whereas (13%) of the respondents were programmers and system designers, and finally, Web developers and systems designers (2%).

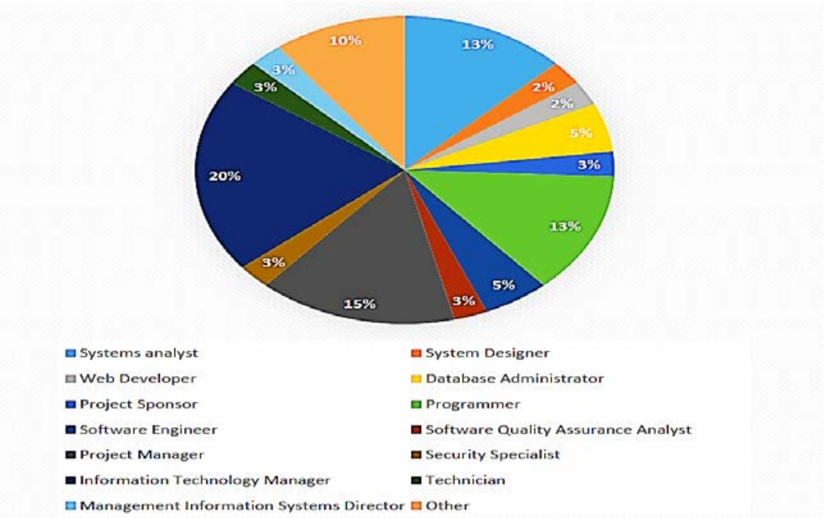

Figure 3: Participants' roles.

4 Analysis & Discussion

The survey shows interesting results and analysis of the software development firms' readiness to adopt the CMMI model (methods and practices). We applied the Statistical Package for the Social Sciences (SPSS). The survey shows interesting results and analysis of the software development organizations. The results show that the software firms were not widely utilizing or applying software engineering practices methods. It also shows inadequate software quality assurance as well as requirements reviewing. In addition to improper use of configuration management systems and creating or release baselines. Moreover, unclear controls on configuration items and inconsistent change requests. The results indicate that most of the software development firms/organizations in Saudi Arabian firms do not have sufficient awareness of CMMI adoption, although they are aware of the CMMI framework and use a form of CMMI programs to establish software products. The lack of awareness of the CMMI was the reason given by the respondents. It states the people are not fully aware of the concept, the organization does not follow CMMI practices in the development of the software process. In addition, it is also stated most of the firms have never considered the concept.

Table 1 illustrates CMMI process areas at level two (Managed), which is represented by seven process areas: REQM, PP, PMC, SAM, MA, CM, and PPQA covered by questions from 1 to 16. As a whole, the majority of the private companies and government agencies in Saudi Arabia were implementing process areas by group effort. By looking at Table 1, it can be seen that means ranged from 2.74 for the PMC process area to 3.15 for REQM and PP process areas for all process areas except SAM 3.36. In general, the capabilities of these processes are Level 1 (Performed) except SAM is Level 2 (Managed). The reason for SAM is that the companies have to deal with an external party.

As a result, most companies establish agreements with suppliers and continue to be maintained by both parties.

Table 1: Level 2 (Managed)

	Process Areas (PA)	PA-Mean	Std. Dev	Result
1	Requirements Management	3.15	1.113	Performed
2	Project Planning	3.15	.988	Performed
3	Project Monitoring and Control	2.74	1.013	Performed
4	Supplier Agreement Management	3.36	1.189	Managed
5	Measurement and Analysis	2.86	1.285	Performed
6	Configuration Management	3.02	1.076	Performed
7	Process and Product Quality Management	2.86	1.288	Performed

In Table 2, information of the process areas at maturity level 3 (Defined). This level has eleven-process areas RD (Requirement development), TS (Technical Solution), PI (Product Integration), VER (Verification), VAL (Validation), OPF (Organizational Process Focus), OPD (Organizational Process Definition), OT (Organizational Training), IPM (Integrated Project Management), RSKM (Risk Management) and DAR (Decision Analysis and Resolution) covered by questions from 17 to 42. As for the table data, the means starting from 2.79 for the OPF process area to the highest mean of 3.29 for the RD process area because the companies need to analyze customer's requirements, products, and product components. The capability for all process areas at this level is classified at level 1 (Performed).

Table 2: Level 3-Defined.

	Process Areas (PA)	PA-Mean	Std. Dev	Result
1	Requirements development	3.29	.927	Performed
2	Technical solution	2.99	1.05	Performed
3	Product integration	2.92	.978	Performed
4	Verification	2.86	1.182	Performed
5	Validation	3.28	.997	Performed
6	Organizational process focus	2.79	1.170	Performed
7	Organizational process definition	3.03	1.547	Performed
8	Organizational training	2.96	1.226	Performed
9	Integrated project management	3.16	.910	Performed
10	Risk management	2.88	1.196	Performed
11	Decision analysis and resolution	2.95	1.169	Performed

Table 3 represents information of the process areas at maturity level 3 (Defined) with eleven-process areas: RD, TS, PI, VER, VAL, OPF, OPD, OT, IPM, RSKM, DAR covered by questions from 17 to 42. The means are from 2.79 for the OPF process area to the highest mean of 3.29 for the RD process area, because the companies need to analyze customer's requirements, products, and product components. The capability for all process areas at this level is classified at level 1 (Performed).

Table 3: Quantitatively Managed.

	Process Areas (PA)	PA-Mean	SD	Result
1	Organizational process performance	2.62	1.33	Performed
2	Quantitative project management	2.86	1.55	Performed

Table 4 demonstrates the result analysis of the Optimizing level. It contains questions from 46 to 49. The Optimizing level has two Process Area CAR (Causal Analysis and Resolution) and

OPM (Organizational Performance Management) divided into 4 questions. As a table, shows that their means are closed together which means the majority of companies cannot discover causes of selected output and they cannot undertake the actions to improve process performance.

Table 4: Optimized

	Process Areas (PA)	PA-Mean	SD	Result
1	Organizational Performance Management	3.05	1.297	Performed
2	Causal analysis and resolution	3.00	1.124	Performed

Consequently, that the majority (79.2%) of Saudi Arabian software firms are assessed at levels 2. These statistics show the expected outcome that most Saudi Arabian software organizations/firms are beyond level 1 so high-level individual efforts are not needed to develop high-quality software products. The report indicates that most of all reporting CMMI firms have been assessed at Level 2. Thus, most Saudi Arabian software firms are inside the Level 2 range. Therefore, Saudi Arabian software industries might require time and cost to make progress for more advanced and sophisticated practices for Levels 3, and 4.

4.1 Preprocess Areas correlation

4.1.1 Correlation between SAM and PPQA

The line graph shows the correlation between SAM and PPQA (Process and Product Quality Management). We have found the correlated is week negative correlation value of (-0.0647).

4.1.2 Correlation between RSKM and DAR

Figure 4 illustrate the correlation between RSKM and DAR. The correlation between them is a strong positive correlated value of (0.823).

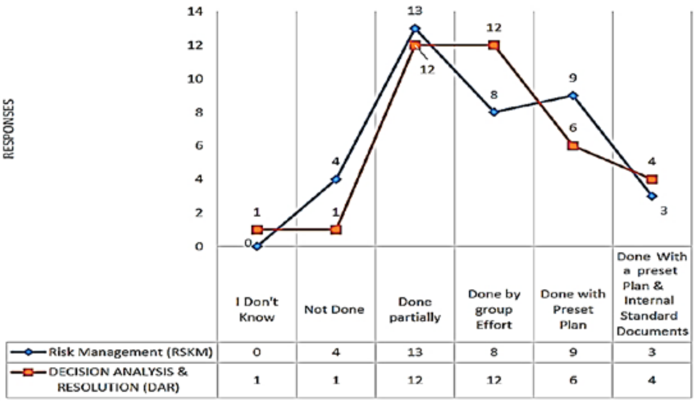

Figure 4: Correlation between RSKM and DAR.

4.2 Process Areas Regression

The general objective of multiple regression is to discover more about the relationship between several process areas and a one-process area. The next subsection shows two studied regressions.

4.2.1 Requirements Management (REQM) Regression

Figure 5 shows the regression between the Requirement Management process with PP, PMC, SAM, IPM, RSKM, and QPM (Quantitative Project Management). The most affecting process area is PMC that because of the responsibility of controlling and monitoring the products. Consequently, the SAM process has no impact on REQM.

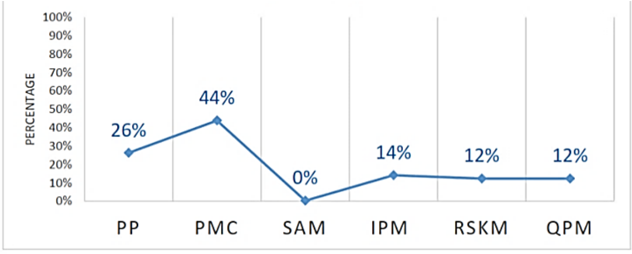

Figure 5: Requirements Management (REQM) Regression.

4.2.2 CAR Regression

Figure 6 shows the regression between CAR with MA, CM, PPQA, and DA. The effect of CAR from a set of process areas ranged between 12-26%. As a result, there is no improvement in the level of productivity and no reduction in cost, this ratio indicates the negative impact on the area of operations.

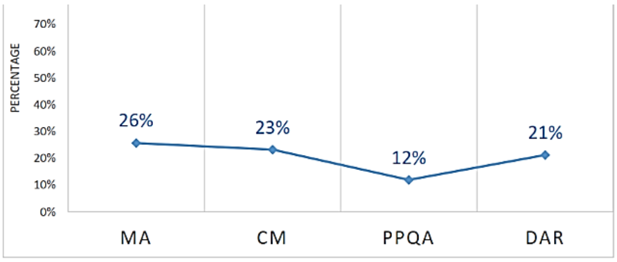

Figure 6: Causal analysis and resolution (CAR) Regression

4.3 Reliability and Validity Analysis Result

The result of 22 Process Area was measured by using ALPHA Cronbach reliability. The result of the alpha test is 0.946, which falls, in the excellent range.

5 Conclusion

This research attempted to check the adoption of software development methods and employees' opinions about how well CMMI practices were being used in the company. The data was collected from survey responses through Web services and analyzed using SPSS. The results clearly show that the awareness and adoption of software development standards are low. Therefore, it is necessary for Saudi Arabian software firms should adequately adopt the CMMI model as a framework that provides software development firms with the guidelines and practices required to improve the process of software development including the monitor and the measurements of products and services improvement. Such integration can boost to improved practices for the production and release of products with high quality. This practice will raise the competitiveness of Saudi Arabian software industries. The findings in this research assure the value and importance of CMMI model for achieving software development benefits. One of the limitations of this analysis is the sample data size and the lack of clarity of the findings. Hence, it is necessary to increase the sample size in future studies to achieve more accurate assessments of unknown parameters. However, the ideas acquired from this study will encourage future research as well as deeper studies and discussions on the adoption of the CMMI model in Saudi Arabian software development firms to become more competitive in the industry. Moreover, as future directions, we could investigate the possibility of continuously evaluating the improvement regarding CMMI awareness and its implementation in Saudi Arabian software development firms and the critical factors affecting each level of maturity. In addition, study the impact of CMMI adoption in Saudi Arabian software firms in association with the information stating that such initiatives can increase product quality [30], productivity [31], and business value and customer satisfaction [32]

6 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

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