

An Unified Testing Process Framework for Small and Medium Size Tech Enterprise with Incorporation of CMMI-SVC to Improve Maturity of Software Testing Process

Md. Tarek Hasan¹, Somania Nur Mahal¹, Nabil Mohammad Abu Bakar¹, Md. Mehedee Hasan¹,
Noushin Islam¹, Farzana Sadia² and Mahady Hasan¹

¹Department of Computer Science and Engineering, Independent University Bangladesh, Dhaka, Bangladesh

²Department of Software Engineering, Daffodil International University, Dhaka, Bangladesh

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Abstract: Software testing service provides a quality assurance approach for evaluating and improving the quality of software. While various obstacles may arise in the software testing services context. Most of the time, testing service quality is not always as expected. This paper illustrates the main motive is to improve the practice areas of the software testing process so that small software companies can enhance the maturity levels. We conducted surveys and collected data from 11 small software companies in Bangladesh to assess the current testing service. The survey's results revealed the gaps in their CMMI-SVC practice areas and also pinpointed potential improvement of practice areas. This document presents a made strides system pointing at the exposure of how to tailor key practice areas of CMMI SVC in the testing process. We proposed a framework that is based on a unified testing model. By following the proposed steps any software companies can enhance their maturity level.

1 INTRODUCTION

Software testing assumes a significant part to ensure the effective performance of software applications. At the same time, it could be costly in the future or at a later stage of development (Wen-Hong, Liu & Xin, 2012).

According to studies, tiny software business or start-ups are not capable of dealing with risk management in terms of time and cash for chance examination due to low budgets and less manpower (Sharma & Dadhich, 2020). To minimize risk, testing should hire competent personnel to experiment internal data and put the experimental data for client's use (Silva, Soares, Peres, de Azevedo, Pinto, & de Lemos Meira, 2014).

Therefore, CMMI-SVC provides a view of the impact of implementing a service-delivery procedure. For that, a standard process model can facilitate sharing of common understanding of advanced technology (Kusakabe, 2015). "The CenPRA testing cycle" can be the reason for working on the testing in terms of technical aspects so that organizations can

resort the CMMI model to enhance the testing process (Bueno, Crespo, & Jino, 2006).

There could be a variety of issues in the field of software testing services. In this manner, it is significant for the two suppliers and customers to survey the quality and development of test administrations and thusly further develop them. CMMI for services can be used as guidance for organizations with effective process areas (PAs) (Raksawat, & Charoenporn, 2021). Our purpose is to connect CMMI-SVC process areas with testing best practices to achieve maturity level 02 at least.

In our country, many organizations seasoning their in-house software testing activities which are devoted to giving software testing services (Raksawat, & Charoenporn, 2021). If they need, they can reevaluate their product testing needs to different firms which will concentrate on software development activities with experts. This offer may improve predictable software quality, maintain the deadlines and increase time to concentrate on development (Raksawat, & Charoenporn, 2021).

Today, testing is the most challenging activity used by organizations, but they have a lack of

knowledge about testing services. According to our survey, almost 52.62% of companies follow the quality assurance approach and 43.56% follow validation and verification. Only 34.65% of the company partially maintains the quality and process performance objectives for the work.

To understand the challenges of the testing services, we conducted an online survey with 11 small software firms (SMEs). Project Manager, Test Manager, CTO, System Analyst, Tester, Software Engineer and Developer were the main roles in the survey. We prepared questionnaires for them and questions were based on software testing best practice areas mapping with CMMI-SVC process areas.

The key questions of this research is given below,

- Q1. How organizations maintain the quality assurance activities?
- Q2. What's their approach to convey administrations as per administration arrangements?

The prime targets of this paper is to recognize the major testing services challenges of current practice and provide them guidelines to enhance their maturity level. For that, we reviewed other research papers. Then we tried to find out the gaps through conducting surveys with 11 small software firms. As a result, we get that most of the company doesn't follow testing process areas properly; some of them partially maintain the quality and process performance objectives for the work, the rest of them unable to follow as they belong to start up business.

To eradicate this problem, we propose a framework that would consider the budget limitation, resources, testing timeline and eventually maximize the maturity level to 2 and above.

2 RESEARCH BACKGROUND

Software testing plays a vital role in delivering a complete bug-free product. Various types of exploration have been directed all over the world to perceive different types of practices and issues related to CMMI-SVC.

The major goal of this paper is to improve the practice areas of the software testing process so that small and medium software organizations can achieve higher degrees of maturity. For that, we have concentrated on last ten years' research. Those researches were conducted to improve services, performance & customer satisfaction which actually suggest following certain terms to improve processes (Kundu, Manohar, & Bairi, 2011).

There are several test process improvement frameworks available, but they are too vast and complex for smaller firms to use. A minimum test practice must be followed in small and medium software company.

They suggest avoiding the negative effects of perspectives and process distortion by including the entire organization in the test practices and their improvement are other concerns made in the creation of the practice framework. Their framework is evaluated by actual use within the same company and observations were noted during the first year of use. The minimal test practice framework was originally developed in a case study at a small and emerging company in Sweden. They suggest a potential extension of the study would be to try to implement the framework in other organizations in comparable situations. It will be fascinating to see how the structure is modified to accommodate new scenarios (Daniel Karlstr, Per Runeson & Sara Nord, 2010).

Some researchers discover their own testing process like CenPRA, SPI, AgileQA-RM under the process perspective improvement of CMMI model (Silva, Soares, Peres, de Azevedo, Pinto, & de Lemos Meira, 2014), (Chunli, & Rongbin, 2016), (Bueno, Crespo, & Jino, 2006). Software testing needs to identify the best-used models and integrate those models in process activity for improvement (Wen-Hong, Liu, & Xin, 2012) while considering risk factors to reduce the risk and manage with efficiency (Sharma, & Dadhich, 2020). Different test phases would be able to detect defect processes (Garousi, Arkan, Urul, Karapıçak, & Felderer, 2020), focused on existing problems, and discussed how CMMI helps improve quality control (Chunli & Rongbin, 2016). They discussed analyzing the process area using related process areas components and facilitating them by sharing a common understanding with comparison by using new technology to examine each maturity model (Hashmi, Lane, Karastoyanova, & Richardson, 2010). As we are discussing the existing processes of the company and identifying what could be the practice areas of the software testing process so that small and medium software organizations can achieve higher degrees of maturity or at least follow minimum process. The goal of our survey is to suggest a unified testing model for small and medium software companies to improve their processes.

3 RESEARCH DESIGN AND METHODOLOGY

The prime intension of this perusal is to improve the practice areas of the software testing service so that small software firms will be able to reach maturity level 3 and above.

As we are concerned about software testing services, we are trying to follow key questions Q1 and Q2 which are mentioned in the introduction part. We are analysing scenarios of current procedures followed by small software organizations by using these research questions.

In previous research, many researchers were conducting their research based on improvement of services, performance, and customer satisfaction and suggested following certain terms to improve in processes (Kundu, Manohar & Bairi, 2011). They also analysed the process area using related process areas components and facilitating them by sharing the common understanding by using new technology (Hashmi, Lane, Karastoyanova, & Richardson, 2010). Overall, all the related work was based on the improvement of better performance in terms of CMMI-SVC. But we are discussing the existing processes that small software firms follow and providing them suggestions to improve services, performance and customer satisfaction. According to our objectives of this paper which is based on the major testing process challenges of current practice and evaluate the maturity of small software firms in Bangladesh, we reviewed other research papers so that we can get a clear concept regarding this topic. Then we tried to find out the gaps through conducting surveys with 11tech SMEs. We have prepared a survey questionnaire and sent it to the lead tester of these SMEs and those 11tech SMEs are classified based upon the following metrics: Age, Size, Project Based/Service Based, Number of Employees and Location (City). After analysing the data, we can understand the process or methods that company's currently following and the gaps of their activities. Finally, we proposed a framework which would eradicate their lacking and consider the budget limitation, resources, testing timeline and eventually maximize the maturity level to 2 & above.

11tech SMEs have been chosen for our research and classified based upon the following metrics: Age, Size, Project Based/Service Based, Number of Employees and Location (City). We have prepared a survey questionnaire and sent it to the lead tester of these SMEs also.

To evaluate the existing testing practices, we collect data, though both online and offline survey.

To evaluate the data, we followed two methods, Analysing Factors & Reliability analysis.

Factor analysis used to assess the observable variables such as performance on specific practice areas. It's also useful for summarizing a large amount of observations into a smaller number of factors. At the early stage of the survey, we set the following 3-scale for each question: 1-No (Not followed), 2-Partial (Partially followed), 3-Yes (Followed). Then we calculate the average value of each practice area to assess the maturity of those organizations and be able to understand the gaps of their following process areas (PAs).

After collecting data, we followed Reliability analysis. Basically, reliability analysis refers to the consistency of measurement. This method can be used to evaluate the survey questionnaire. The mean, median, and mode are 3 ways of calculating the average. We can use the scale for each question to assess responses from surveys and each respondent represents their activities, whether they conduct testing services or not.

4 FINDINGS

4.1 Trend Followed by Companies

11 tech SMEs have been chosen for our research and classified based upon the following metrics: Age, Size, Project Based/Service Based, Number of employees and Location. We have got 24 responses from 11 companies different roles for 23 questions set considering different practice areas of CMMI-SVC. We considered 11 practice areas for our research, such as PLAN, PQA, IRP, MPM, WMC, RDM, PR, VV, II, ROM and EST.

We tried to know the trends of small software companies, therefore we conducted a survey. For that, we calculate the average value of each question which is based on practice areas of CMMI-SVC. Table 1 shows the percentage of process areas, which refers to small software company trends.

In table 1, we analyse the average value of each process area that a small company usually follows for testing services. We can summarize that almost 52.62% of companies follow the quality assurance approach and 34.65% of the company partially maintains the quality and process performance objectives for work. We can understand the trends and reason behind fluctuation maturity levels. The percentage of LI goes downward when the maturity level goes up; The PI has an upward trend with the level. NI has the significant value for Level 0 & 2.

Table 1: Percentage of following process areas.

Name of process areas	Followed	Partially followed	Not followed
(PQA)	52.62%	22.88%	27.98%
(WMC)	76.9%	7.7%	15.4%
(IRP)	46.2%	7.7%	46.2%
(MPM)	34.65%	34.65%	30.75%
(PR)	61.5%	38.5%	0%
(VV)	43.56%	0%	33.3%
(RDM)	69.2%	0%	30.8%
(PLAN)	36.4%	27.3%	36.4%
(II)	30.8%	34.65%	38.42%
(ROM)	53.8%	7.7%	38.5%
(EST)	30.8%	30.8%	30.7%

Who is not following any testing process our proposed solution will guide them to follow and improve testing processes.

4.2 Reliability Analysis

Reliability analysis alludes to the properties of estimation scales and the things that create the scales (Gemino, Horner Reich, & Serrador, 2021). Using reliability analysis, we can verify our questionnaire is related to practice areas or not. Basically, our survey questionnaire refers to 23 questions which are based on 11 practice areas of CMMI-SVC. To measure the scale of reliability for those questionnaires, we followed Cronbach's Alpha method that is a coefficient of reliability. Cronbach's Alpha is a model of inside firmness, in view of the normal between thing connection.

In table 2, Cronbach's Alpha refers to the average inter-item correlation. Number of items refers to 23 survey questionnaires. According to general rule, the acceptable level of reliability α is 0.6-1.0 range (Gemino, Horner Reich, & Serrador, 2021). But we got a value of alpha 0.943 which indicates a strong satisfactory level from the survey questionnaire.

Table 2: Unwavering quality insights.

Cronbach's Alpha	Cronbach's α Based on Standardized Things	Item No.
0.943	0.940	23

4.3 SCAMPI

SCAMPI is a standard method to evaluate each process area of CMMI (Rahmani,Sami, & Khalili, 2016). It consists of a series of activities including interviews, checking documents, and analysing the results of questionnaires and surveys. The weighting can be seen in table 3.

Table 3: Scampi weighting.

Abbreviation	Criteria	Weight
NI	Not implemented	0
PI	Partially Implemented	1
LI	Largely Implemented	2

4.4 Questionnaire Result

The survey questionnaire was distributed to 11 tech SMEs. Project Manager, CTO, Test Manager, System Analyst, Tester, Software Engineer and Developer were the key roles of this survey. The distribution of the questionnaires was assessed based on the SCAMPI method. Here we marked each question and tried to figure out the percentage of SCAMPI value so that we can assess maturity level. Since most companies are new, that's why we focused on maturity level 1, level 2 and level 3.

Figure 1 is showing the score of SCAMPI value based on the practice area of level1. Here we can summarize that, 'E', 'F', 'G', 'K', 'A' software firms achieve 65-100% of level 1. As 'D' I 'H' 'J','C' achieve 30%-60% of Level 1.'C' and 'D' companies have lower scores than other companies, they need improvement on practice areas. Through Figure1, we can understand the trends of practice areas followed by small software firms also.



Figure 1: Score and percentage of SCAMPI value based CMMI-SVC level-1.

Figure 2 is showing the score of each company based on the practice area of CMMI level 2. As a result, 'E', 'F', 'G', 'K' companies achieve 70%-95% of Level2 approximately. 'D', 'B', 'I', 'J' achieve almost 30%- 45% of Level2. Due to less percentage of SCAMPI score, 'D', 'H', 'C', 'J' companies have to be more concerned about the practice area of CMMI level-2.



Figure 2: Score and percentage of SCAMPI value based CMMI-SVC level-2.

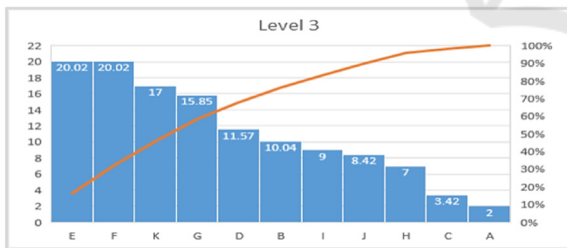


Figure 3: Score and percentage of SCAMPI value based CMMI-SVC level-3.

The score of SCAMPI value of level 3 has been analysed in Figure 3. As a result, 'E', 'F', 'G', 'K' achieve 65%-90% of maturity level 3 only. We can understand 'A', 'C', 'H', 'J', 'I', 'B', 'G' to achieve 10%-60% of Level-3 only. As they are unable to follow the practice area of CMMI-SVC Level-3. So they have to be more concerned with enhancing their testing services properly.

4.5 Questionnaire Result

In this section, we try to visualize the overall trend of Tech SMEs so that we can understand which process areas they need to improve. For that, we calculate the average value from each question based on each process area.

Figure 4 is showing the trend of the company being analysed. Our survey questionnaire was based on 11 practices of CMMI-SVC. From Figure-4, we can summarize that most of the small software firms follow MC for software testing. But the average value of PLAN, MPM, II is below 50% (below avg. value 1) which indicates their failure on those practice areas. As most SMEs are facing difficulties in providing testing services due to lack of planning on their project.

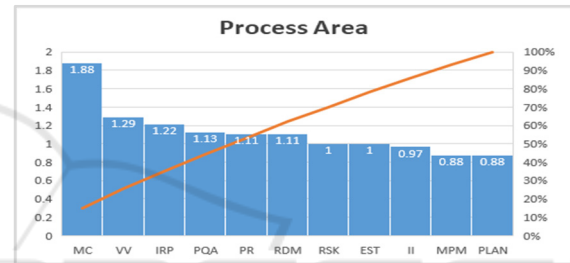


Figure 4: Visualization on overall trends of each process area.

5 PROPOSED SOLUTION

After analysing the data, we propose a framework which consider the budget limitation, resources, testing timeline and eventually maximize the maturity level to 2 & above. The framework for little and medium program companies is designed to improve practice areas of CMMI-SVC standardized software testing services along with software testing best practices.

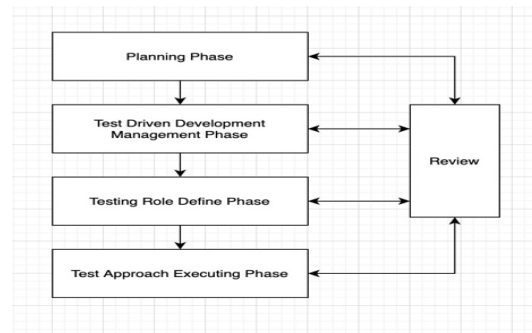


Figure 5: Proposed framework.

We proposed a framework that divided the testing process into different phases that are interrelated to each other. Our approach is to review each process so that it will make a loop to have a longer lasting solution.

Composition of our proposed framework is shown in Figure 5.

Testing process is divided into different phases that are interrelated to each other. Different phases are given below.

5.1 Planning Phase

In the planning phase we actually plan the objective, what we are going to test on the priority basis. By maintaining standard & using tools who is going to test what and how. By the plan objective we must satisfy mentioned attributes.

Table 4: Prioritization of List of Testing Objectives of Start-ups.

Objective	Priority	Key attributes
Plan the test policy and prepare policy document	High	a. Test standards b. Testing tools c. Testing improvements d. Test budget estimation e. Risk Analysis
Prepare Quality Management Plan	Medium	a. Quality objectives b. Ensure key deliverables c. Roles & responsibilities d. Testing tools
Define test strategies and align QA with product business objectives	Medium	a. Test scope b. Setting Industry standards c. Time constraints d. Budget constraints
Prepare test Plan	High	a. Test items b. Setting pass & fail criteria c. Test approaches d. Schedule e. Risks f. Responsibilities g. Deliverables
Prepare Test Cases	High	a. Feature test b. Description c. Test steps d. Test data e. Result Data

5.2 Test Driven Development Management Phase

This phase is based on two main objectives Test-Driven Development and Pair Programming. Since we are in development phase we have to test & review codes as much as possible to optimize re-work and improve process which save both the time and money.

Table 5: Phase of test-driven development management.

Objective	Priority	Key attributes
Employ Test- Driven Development	High	a. High quality Optimization of development costs. b. Simplification of code c. Executable documentation
Employ Pair Programming	Low	a. High quality code b. Knowledge sharing

5.3 Testing Role Define Phase

In role defining phase job should distribute as precise as possible, share the responsibility while having less resource where multiple responsibilities can be looked over by single role.

Table 6: Testing role define phase.

Standard Role	Core Responsibilities	Start-ups Shared resources
Software Test Engineer	Test overall system	Tester, Developer
Test analyst	Identify test conditions and features to develop test scenarios	Test lead, Tester, Developer
Test automation engineer	Develop scripts to run automated test	Tester, Developer
Software Developer in Test	Develop Tool to support testing	Tester, developer
Test architect	Design Complex test infrastructure, select tools for implementation	Lead tester, Tester
Test architect	Prepare test strategy, control testing process and team members	Lead tester, project manager

5.4 Testing Approaches Execution Phase

After having the planned objective and role based resource, now we can approach the tasks to execution to achieve certain goals. In the below mention table we are going to pick a task based on priority and would try to achieve specified goal.

Table 7: Phase of testing approaches.

Key tasks	Priority	Achievable goal
Arranging a testing plan from the early stages of the advancement	High	Distinguish and settle bugs and glitches as Before long as conceivable
Reviewing requirements	High	Engage testers in with stakeholders to review & analyse requirements
Testing Regularly	Low	a. Doing littler tests more regularly all through the improvement stages b. Making a ceaseless criticism stream permits for quick approval and enhancement of the framework
Team collaboration	Medium	Tightly collaborate to achieve broad skill sets. Involve testers within the advancement prepare and designers in testing exercises, making an item with testability in intellect.

5.5 Review Phase

Above mentioned Each phase will go through this review phase, there must be a schedule review phase to have each phase review & outcome to enrich any process. By this phase we actually review all other phases

6 CONCLUSION

The main goal of the study is to extend the maturity of small and medium software firms based on testing service perspective. For that, we conduct a survey on software testing best practice areas mapping with

Table 8: Task of review phase.

Key tasks	Priority	Achievable goal
Conduct review meeting	Medium	a. Present the item to the rest of the commentators. b. All the members need to acknowledge the item, recommend alterations, and examine timeframes.
Walk through Assembly	High	a. Reviewers look at the code of the item alluded to, its plan, and recorded prerequisites b. Detect bugs in the code c. Q & A with developer
Inspection Session	High	a. Decides the extra properties of the item agreeing to the prerequisites b. Grow starting benchmarks c. Check to see in case past bugs are still display

CMMI-SVC process areas. Basically, our research is based on software testing and a few specific practice areas like PPQA, REQM, SD, WMC, WP, IRP, QPM.

While the different research methodology proved to be successful as the following process and practice area. We have gone through their existing practices & processes, relate them with standard practices & processes to provide suggestions to have a better maturity model, better performance & client satisfaction.

We received 24 responses from 11 tech SME. As a result, we can understand their gaps and activities regarding software testing service. Through result analysis, we elaborate on the practices of CMMI-SVC based on software testing. Finally, we propose a framework that would consider the budget limitation, resources, testing timeline and eventually maximize the maturity level to 2 & above.

For future work, we suggest focusing more on those practice areas to optimize gaps which has been less followed and bigger impact. We can learn from the trend, how and why that percentage of the following practices fluctuate. Last but not the least the NI has a significant percentage which means that they are not following those practice areas. So we must research on those practices why they are not followed at all. Need to figure out common aspects and guide them in such a way that they must at least follow those partially. We will conduct another survey to validated

proposed plan and focus on more comparative evaluation.

This action is a continuing improvement process for any organization. But standard processes and existing processes have to parallel. To improve any certain process or practice one has to dive deep into that specific domain and find out all possible tasks related to that. The future work will have a significant impact regarding performance improvement and enhance their maturity model.

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