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Assessing Software Processes over a New Generic Software Process Assessment Tool

Abstract[4]

Performing process improvement to deliver qualified products with the expected cost on time has been a requirement for organizations targeting to be successful in the software market. Software organizations usually perform process improvement based on well-known process assessment frameworks such as CMMI and ISO/IEC 15504. A number of derivatives of CMMI and ISO/IEC 15504 have been developed and they are being updated. As a result of this, the software process assessment tool based on them needs to be updated. Process assessment requires judgment and there is an unavoidable manual work. However, there are also opportunities for assessment automation. Therefore, there is a need for a generic software process assessment tool to define process assessment models and facilitate assessment. The existing tools do not meet the expected features of a software process assessment tool completely, as they have generally been developed for single process assessment models. In this study, we present GSPA, a generic software process assessment tool, which has been developed to support all structured process assessment models with its generic framework, facilitate assessment, support parallel assessment and present the reports in a well-structured way to the assessors. A multiple case study has been conducted to measure the sufficiency and the contributions of the tool.

Keywords: software process assessment, software process improvement, Software Process Assessment Tool, CMMI, ISO/IEC 15504

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[4] This study has been supported by the Turkish Scientific and Technological Research Council of Turkey (TUBITAK), Project 113E528.

1. Introduction

Delivering qualified products on time with the expected cost has become a common purpose of each company which aims to make profit in the globalized world. On this account, companies focus on process improvement studies which reveal the current situation of processes and the necessary steps to be taken in order to improve processes. CMMI[5] and ISO/IEC 15504[6] are the most popular process assessment models used in software process assessment studies by software organizations[7]. In addition, process assessment models which have been customized for various industries such as Auto SPICE[8], Medi SPICE[9], Enterprise SPICE[10] and Brazilian Software Improvement[11] are used for software process improvement. When the studies conducted between 1990 and 2009 were examined, it was noticed that 52 process assessment models, most of which were based on CMMI[12] and ISO/IEC 15504[13], were developed[14]. Furthermore, the historical developments of process assessment models demonstrate that even the designers of the most widely-accepted models such as the SEI and ISO/IEC create new versions of existing standards in order to adapt

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5 CMMI Product Team, *CMMI® for Development, Version 1.3 CMMI–DEV, V1.3*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania 2010.

6 *ISO 15504–5 Information Technology – Process Assessment – Part 5: An Exemplary Process Assessment Model*, ISO/IEC 2006.

7 B. Aysolmaz, A. Yıldız, O. Demirörs, *BG-SPI: Yinelemeli Yazılım Süreç İyileştirme Yöntemi*, Yazılım Mühendisliği Sempozyumu, Ulus 2011, pp. 163–169.

8 A. Sig, SIG Automotive, *Automotive SPICE ® Process Assessment Model*, 2010, pp. 1–146, available http://www.broadswordsolutions.com/wp-content/uploads/2014/09/A-SPICE_REFERENCE_MODEL.pdf

9 F.M. Caffery, A. Dorling, *Medi SPICE Development*, "Journal of Software Maintenance and Evolution Research and Practice", August 2009, pp. 255–268.

10 A. Mitasiunas, L. Novickis, *Enterprise SPICE Based Education Capability Maturity Model*, in: *Workshops on Business Informatics Research*, eds. L. Niedrite, L. Strazdina, B. Wangler, vol. 106, Springer Berlin Heidelberg, Berlin 2012, pp. 102–116.

11 K.C. Weber, E.E.R. Araújo, A. Regina, C. Rocha, C.A.F. Machado, D. Scalet, C.F. Salvi-ano, *Brazilian Software Process Reference Model and Assessment Method*, Lecture Notes on Computer Science, vol. 3733, 2005, pp. 402–411.

12 CMMI Product Team, *CMMI® for Development, Version 1.3 CMMI–DEV, V1.3*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania 2010.

13 *ISO 15504–5 Information Technology – Process Assessment – Part 5: An Exemplary Process Assessment Model*, ISO/IEC 2006.

14 C.G. von Wangenheim, J. Carlo, R. Hauck, C.F. Salviano, A. Von Wangenheim, *Systematic Literature Review of Software Process Capability/ Maturity Models*, in "11 Proceedings of the 12th International Conference on Product Focused Software Development and Process Improvement", May 2010, pp. 2–5.

to the rapidly changing sector of software (ISO/IEC 12207[15], ISO/IEC 15504[16], CMMI v1.2[17], CMMI v1.1[18], CMMI v1.2[19], CMMI v1.3[20]). When a new version of a model emerges, this new version has to be adapted by companies and a new assessment has to be performed.

Performing process assessment manually has its own challenges. Arrangement of the findings and evidence is the most time consuming activity and might be complicated when the amount of evidence is considered. It is also not easy to comprehend and analyze the outputs emerging from the assessment while performing a paper based assessment[21]. Therefore, importance has been given to automation which allows decreasing the time for repeated tasks[22]. For that purpose, a number of software process assessment tools have been developed to increase the efficiency of process assessment since tool support has an important place in terms of cost and time efficiency in software process assessment studies[23]. Process assessment tools[24] have been developed mainly for either CMMI

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15 *ISO/IEC 12207 Systems and Software Engineering – Software Life Cycle Processes*, ISO/IEC 2008.

16 *ISO 15504–5 Information Technology – Process Assessment – Part 5: An Exemplary Process Assessment Model*, ISO/IEC 2006.

17 CMMI Product Development Team, *CMMI for Systems Engineering/Software Engineering, Version 1.02 (CMMI-SE/SW, V1.02)*, Software Engineering Institute, Carnegie Mellon University, December 2001, Pittsburgh, Pennsylvania 2000.

18 CMMI Product Team, *CMMI for Software Engineering, Version 1.1, Staged Representation (CMMI-SW, V1.1, Staged)*, Software Engineering Institute, Carnegie Mellon University, December 2001, Pittsburgh, Pennsylvania 2002.

19 CMMI Product Team, *CMMI for Development, Version 1.2*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania 2006.

20 CMMI Product Team, *CMMI® for Development, Version 1.3 CMMI–DEV, V1.3*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania 2010.

21 D. Homchuenchom, C. Piyabunditkul, H. Lichter, T. Anwar, *SPIALS: A Light-weight Software Process Improvement Self-assessment tool*, Malaysian Software Engineering Conference, December 2011, pp. 195–199.

22 F. Çelik, B. Bozlu, O. Demirörs, *The Tool Coverage of Software Process Improvement Frameworks for Small and Medium-Sized Enterprises*, 10th International Conference, PROFES 2009, pp. 290–302.

23 S. Gazel, E.A. Sezer, A. Tarhan, *An Ontology Based Infrastructure to Support CMMI-Based Software Process Assessment*, "Gazi University Journal of Science" 2012, vol. 25, no. 1, pp. 155–164.

24 R. Hunter, R. Street, G. Glasgow, G. Robinson, R. Court, I. Woodman, M. Court, *Tool Support for Software Process Assessment and Improvement*, "Software Process: Improvement and Practice" 1997, vol. 3, John Wiley and Sons Ltd; *SW-CMM v1.1 Interim Maturity Toolkit*, available: http://www.spipartners.com/english/tools/index.html; W. Walker, A.J. House, W. Park, *SPICE Assessments Using the SEAL Assessment Tool*, Conference ISCN 1996; *SPiCE – Lite Assessment Tool*, available: http://www.spicelite.com); *CMM Quest V1.3* (available: http://www.cmm-quest.com; *CMMiPal v1.0* (available: http://www.chemuturi.com/cmmipaldtls.

or ISO/IEC 15504, none of which supports the adjusted process assessment models which have been developed with the customization of CMMI or ISO/IEC 15504. Our previous multiple case study on the existing tools pointed out that there is no tool which meets the expected features such as defining a new model, basic assessment functions related to ratings of goals and practices, and adding evidence coordinately and parallel assessment to support process assessment teams[25]. Therefore, there is a need to develop an automated generic software process assessment tool which has all the necessary features in order to support software process assessment based on various process assessment models.

The purpose of this study is to present the generic software process assessment tool (GSPA) which has been developed by us to achieve basic process assessment functions, to report assessment results, to guide assessors, to evaluate different projects, to provide discovery of their features, and to define various types of structured process assessment models by constructing a generic process assessment framework with combination of CMMI and ISO/IEC 15504 structures. We also present the results of a multiple case study that has been conducted to identify the efficiency and usability of the tool. For the multiple case study, we defined three process assessment examples, all of which performed paper-based with CMMI, ISO/IEC 15504 and Software Agility Assessment previously in three software organizations.

The remaining of this paper is structured as follows: in chapter 2, we present the literature review results based on automated software process assessment tools. In chapter 3, we present GSPA with its meta-model and basic functions. In chapter 4, we explain the application of GSPA through the multiple case study. In chapter 5, we provide the findings obtained during case studies in a detailed way for each case. In chapter 6, we provide the answers to research questions. Finally, the overall findings are concluded and future work which is planned after this study is suggested in chapter 7.

html); *CMMI v1.1 Self-Assessment Tool* (available: http://www.spipartners.com/english/tools/index.html).

[25] O.R. Yürüm, Ö.Ö. Top, A.M. Ertuğrul, O. Demirörs, *Yazılım Süreç Değerlendirme Araçlarının Karşılaştırılması: Bir Çoklu Durum Çalışması*, 8. Ulusal Yazılım Mühendisliği Sempozyumu 2014.

2. Literature Survey

Process assessment tools help an assessor determine the capability of a process in order to manage assessment data and record assessment results during an assessment[26]. The main purpose of the tools is to support assessment so as to minimize the cost and maximize the reliability of assessment reports[27]. A lot of process assessment tools have been developed in an effort to support process assessment with the aim of decreasing time and costs for an assessment. The process assessment tools demonstrated in Table 1 were found at the end of literature review benefiting from certain key words in science related databases.

Table 1. The List of Software Process Assessment Tools

Tool Owner	Tool Name
Software Quality Institute of Griffith University	Appraisal Assistant[28]
Integrated System Diagnostics Incorporated	Appraisal Wizard[29]
Wibas	CMMI Browser[30]
Marc De Smet	CMMI v1.1 Self-Assessment Tool[31]
Chemuturi Consultancy	CMMiPal v1.0[32]
HM&S IT-Consulting	CMM-Quest v1.3[33]
Integrated System Diagnostics Incorporated	Model Wizard[34]
SEAL	SEAL QQ[35]

[26] R. Hunter, R. Street, G. Glasgow, G. Robinson, R. Court, I. Woodman, M. Court, *Tool Support for Software Process Assessment and Improvement*, "Software Process: Improvement and Practice" 1997, vol. 3, John Wiley and Sons Ltd.

[27] F. Çelik, B. Bozlu, O. Demirörs, *The Tool Coverage of Software Process Improvement Frameworks for Small and Medium-Sized Enterprises*, 10th International Conference, PROFES 2009, pp. 290–302.

[28] S.Q.I. Griffith University, *Appraisal Assistant*, available: http://www.sqi.gu.edu.au/AppraisalAssistant/about.html

[29] *Appraisal Wizard and Wizard Lite*, available: http://www.isd-inc.com/tools.appraisalWizard/

[30] *CMMI Browser*, (available: https://www.wibas.com/en/turning-visions/publications/online-tools/cmmi-browser/

[31] *CMMI v1.1 Self-Assessment Tool*, (available: http://www.spipartners.com/english/tools/index.html

[32] *CMMiPal v1.0*, available: http://www.chemuturi.com/cmmipaldtls.html)

[33] *CMM Quest V1.3* (available: http://www.cmm-quest.com/

[34] *Model Wizard*, available: http://isdinc.com/tools.modelWizard

[35] W. Walker, A.J. House, W. Park, *SPICE Assessments Using the SEAL Assessment Tool*, Conference ISCN 1996.

Tool Owner	Tool Name
HM&S IT-Consulting	SPICE 1-2-1[36]
HM&S IT-Consulting	SPiCE-Lite Tool[37]
Marc De Smet	SW-CMM v1.1 Interim Maturity Toolkit[38]

Source: the authors' own work.

These software process assessment tools have been developed to increase the efficiency of process assessment. However, there was no study to measure the sufficiency of the existing software process assessment tools. Therefore, we conducted a multiple case study in order to compare the tools in terms of meeting the expected features. For the multiple case study, the following criteria were determined by taking opinions of experts about process assessment[39]:

Table 2. The List of Comparison Criteria

Criteria Name
Suitability for defining a new model
Suitability for performing an assessment
Reporting automatically
Guiding the assessor
Evaluation of different projects
Suitability for a parallel assessment

Source: the authors' own work.

When accessible software process assessment tools[40] from those listed in Table 1 were compared, Appraisal Assistant[41] got the best result with its reporting

[36] *SPiCE 1-2-1 for International Standard*, available: http://www.spice121.com

[37] *SPiCE – Lite Assessment Tool* (available: http://www.spicelite.com)

[38] *SW-CMM v1.1 Interim Maturity Toolkit*, (available: http://www.spipartners.com/english/tools/index.html

[39] O.R. Yürüm, Ö.Ö. Top, A.M. Ertuğrul, O. Demirörs, Yazılım Süreç Değerlendirme Araçlarının Karşılaştırılması: Bir Çoklu Durum Çalışması, 8. Ulusal Yazılım Mühendisliği Sempozyumu 2014.

[40] *SPiCE 1-2-1 for International Standard* (available: http://www.spice121.com); *CMM Quest V1.3* (available: http://www.cmm-quest.com/); *CMMiPal v1.0* (available: http://www.chemuturi.com/cmmipaldtls.html); S.Q.I. Griffith University, *Appraisal Assistant*, available: http://www.sqi.gu.edu.au/AppraisalAssistant/about.html; *Appraisal Wizard and Wizard Lite* (available: http://www.isd-inc.com/tools.appraisalWizard/); *Model Wizard*, available: http://isdinc.com/tools.modelWizard

[41] S.Q.I. Griffith University, *Appraisal Assistant* (available: http://www.sqi.gu.edu.au/AppraisalAssistant/about.html)

automatically, and supporting different projects properties and functions[42]. Although the Appraisal Assistant[43] got the highest score in terms of suitability for defining a new model, we observed challenges related to association of generic goals with the capability dimension, organization of concept elements and changing the number of capability and maturity levels in the functionality of "defining a process assessment model" in the tool. In addition, it does not meet the expectation of parallel process assessment capability. Besides, it is subject to judgement in terms of user friendly interfaces. Among other software process assessment tools, CMM-Quest v1.3[44] and SPICE 1-2-1[45] were also rated as "fully achieved" in terms of guiding assessors, automated reporting functions, and user friendly interfaces. On the other hand, Appraisal Wizard[46] and the Model Wizard[47] are only suitable for basic assessment functions such as ratings of goals and practices, and adding evidence. When these software process assessment tools were examined as a whole, it occurred that no tool met the expectations of the features completely.

3. GSPA: A Generic Software Process Assessment Tool

We have determined the necessary features that a process assessment tool should have with the help of our previous multiple case study defined briefly in the previous section. In line with the results of the case study, we developed the meta-model of the GSPA tool. The purpose of the meta-model is to provide a generic framework that allows definition of different process assessment models in the tool. Below, we present the meta-model and the use case diagrams which are the main functions of GSPA[48].

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42 O.R. Yürüm, Ö.Ö. Top, A.M. Ertuğrul, O. Demirörs, *Yazılım Süreç Değerlendirme Araçlarının Karşılaştırılması: Bir Çoklu Durum Çalışması*, 8. Ulusal Yazılım Mühendisliği Sempozyumu 2014.

43 S.Q.I. Griffith University, *Appraisal Assistant*, available: http://www.sqi.gu.edu.au/AppraisalAssistant/about.html

44 *CMM Quest V1.3* (available: http://www.cmm-quest.com/)

45 *SPiCE 1–2–1 for International Standard* (available: http://www.spice121.com)

46 *Appraisal Wizard and Wizard Lite*, available: http://www.isd-inc.com/tools.appraisalWizard/

47 *Model Wizard*, available: http://isdinc.com/tools.modelWizard

48 O.R. Yürüm, *GSPA: A Generic Software Process Assessment Tool*, M.S. thesis, Middle East Technical University, Ankara, Turkey 2014.

3.1. The Meta-Model of GSPA

A meta-model consists of classes representing concepts and their relationships to show the connection between the classes[49]. As Lepasaar and Mäkinen indicated, a single meta-model which can be created with a combination of multiple models helps various process assessment models to be supported with a process assessment tool[50].

In addition, the combination of meta-models of several process assessment models into one meta-model allows the compensation of weak sides and an emphasis on the powerful sides[51]. Therefore, we focused on establishing a meta-model by integrating two most known process assessment models which are CMMI and ISO/IEC 15504.

Table 3. Mappings of CMMI, ISO/IEC 15504 and the Meta-Model

CMMI	ISO/IEC 15504	Meta-Model of GSPA
Process Area	Process	Process
Specific Goal	Process Outcome	Specific Outcome
Specific Practice	Base Practice	Specific Practice
Subpractice	-	Subpractice
Typical Work Product	Output Work Product	Output Work Product
Generic Goal	Process Attribute	Generic Attribute
Generic Practice	Generic Practice	Generic Practice
Generic Practice Elaboration	-	Generic Practice Elaboration
-	Generic Resource	Generic Resource
Capability Level	Capability Level	Capability Level
-	Generic Work Product	Generic Work Product
-	Input Work Product	Input Work Product

Source: the authors' own work.

Firstly, we defined the class diagrams of these two models, and then we integrated those two diagrams into one to construct the meta-model. For the

[49] C. Gonzalez-perez, B. Henderson-sellers, *A Meta-Model for Assessable Software Development Methodologies*, "Software Quality Journal" 2005, vol. 13, issue 2, pp. 195–214.

[50] M. Lepasaar, T. Mäkinen, *Integrating Software Process Assessment Models Using a Process Meta-Model*, Engineering Management Conference 2002, vol. 1, pp. 224–229.

[51] S. Jeners, H. Lichter, A. Dragomir, *Towards an Integration of Multiple Process Improvement Reference Models Based on Automated Concept Extraction*, 19th European Conference, EuroSPI 2012, pp. 205–216.

integration, we needed mapping of CMMI and ISO/IEC 15504 concepts. We benefited from the study of Bella *et al*. for mapping[52] and, we renamed the common concepts for our meta-model.

Figure 1 below shows the meta-model of GSPA.

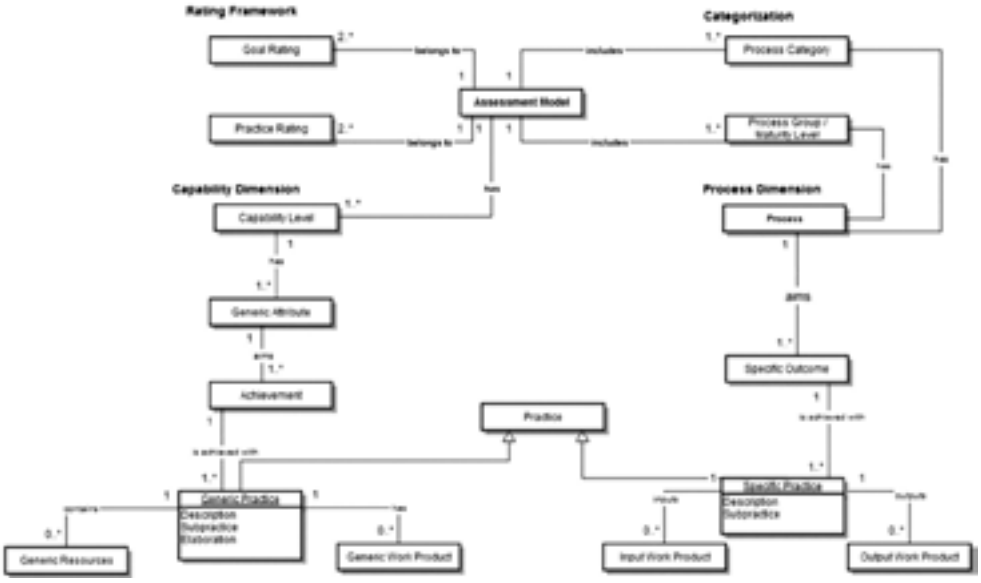

Figure 1. The Meta-Model

Source: the authors' own work.

3.2. Functions of GSPA

GSPA has been developed as a desktop application with Java programming language in Eclipse platform using MySql database. The functions of GSPA are displayed in the following use case diagram. These functions were derived from the case study discussed in section 2, meta-model analysis and the discussions conducted with software process assessment experts.

[52] F. Bella, K. Hoermann B. Vanamali, *From CMMI to SPICE – Experiences on How to Survive a SPICE Assessment Having Already Implemented CMMI*, "Lecture Notes in Computer Science" 2008, vol. 5089, pp. 133–142.

Figure 2. The Use Case Diagram

Source: the authors' own work.

4. The Application of GSPA

We have conducted a multiple case study in order to measure the efficiency of the tool on supporting various process assessment models such as CMMI[53], ISO/IEC 15504[54], and Agility Assessment model[55] and usability of the tool with seven criteria determined in our previous multiple case study. A multiple case study is suitable for this study since we need to examine more than one

[53] CMMI Product Team, *CMMI® for Development, Version 1.3 CMMI–DEV, V1.3*, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, Pennsylvania 2010.

[54] *ISO 15504–5 Information Technology – Process Assessment – Part 5: An Exemplary Process Assessment Model*, ISO/IEC 2006.

[55] Ö.Ö. Top, O. Demirörs, *Agility Assessment Model v1.0*, 2014.

phenomenon. With multiple case studies, our aim was to carry out a certain number of assessments based on a certain number of process assessment models in order to generalize our results about whether the tool supports different kinds of process assessment models or not and get opinions of different process assessment experts about the features of GSPA. We defined the following research questions (RQ):
RQ1: To what extent is the tool sufficient in meeting the expected features?
RQ2: What are the advantages of an automated generic software process assessment tool?
RQ3: What are the weaknesses of the proposed tool?

4.1. Case Study Design

Model Selection: GSPA claims to perform the definition of different process improvement/assessment models. Therefore, we aimed to select the two most common process improvement/assessment models and one new process assessment model to evaluate this property. In addition to common models, we aimed to choose a new process assessment model that is developed with a different purpose but sharing the same structure with these models to observe the flexibility of GSPA to adjustments. That is, the third model should be two-dimensional, having similar elements such as practices and goals with the two most common process assessment models.

Assessor Selection: We wanted to get opinions of different process improvement experts about using the tool. The criteria to identify the assessors were that the assessors either had at least one-year experience in process assessment or completed the Software Quality Management Course with grade AA (90/100), which is one of the courses of the Information Systems program at Middle East Technical University.

Case Selection: We aimed to select three process assessment cases which had been performed manually with the process assessment/improvement models selected for this case study since we had previously wanted to obtain more concrete information about the functionality and usability of GSPA instead of performing a real time assessment in an organization. In order to identify the suitability for performing an assessment, the case should have evidence, practice ratings and comments or notes about the assessment. The assessment cases should have detailed reports to allow the comparison of the assessment results and identification of the boundaries of the automatic reporting capability of GSPA.

4.2. Case Study Conduct

Model Selection: GSPA is based on CMMI and ISO/IEC 15504 frameworks since they are underlying of many process assessment models as mentioned in section 3. Therefore, we chose CMMI and ISO/IEC 15504 as the most common process assessment models. In addition to this, the Agility Assessment Model[56], created for measuring the agility of organizations was determined since it is derived from ISO/IEC 15504 and we wanted to see how to observe the derived process assessment model.

Assessor selection: After the process assessment model selection, three assessors were specified according to their expertise of CMMI, ISO/IEC 15504 and the Agility Assessment Model. Two of the assessors had more than three years' working experience in the process improvement field and the third one was a graduate student who had taken the Software Quality Management Course and got an AA grade from the course.

Case Selection: We identified assessment cases for each of the process assessment/improvement models. The case based on CMMI was performed in an organization working for the defense industry, with 55 employees. The other case related with ISO/IEC 15504 was performed for the Software Quality Management course, one of the courses of Informatics Institute program by the students in an organization having CMMI Level 3 certificate with 100 employees. The last one based on the Agility Assessment Model was performed in a government organization developing web based applications and having 60 employees.

Following these processes, the assessors chose the appropriate process assessment cases based on their expertise areas. Furthermore, each assessor was familiar with the case since the assessors had been involved in the assessment before.

Automated Assessment with the GSPA Tool: In order to see the functionality and usability of GSPA, a few processes and projects were chosen as a sample from the case report instead of identifying all process assessments and inputs in a report for each case.

The first chosen assessment case based on CMMI consists of two process areas which are "Project Planning" and "Organizational Training" and three projects were examined to perform this assessment. The other assessment case is related with ISO/IEC 15504, which includes one process named Quality Assurance and two other projects. The last assessment case based on the Agility

[56] Ö.Ö. Top, O. Demirörs, *Agility Assessment Model v1.0*, 2014.

Assessment Model includes two aspects, namely "Exploration" and "Transition" and two projects were examined for this process assessment.

Then, the assessors who are experts in the related process assessment model performed the assessment with the tool and the tool expert observed the assessors during this period. The assessors were not directed for the functions of the GSPA tool. None of them were familiar with the user interfaces of the tool. They were only told to create a process assessment model and perform a process assessment based on it. They were not given any extra material and documents except the assessment reports. The assessors were asked to perform the following steps during the assessment:

1. Create a process assessment model,
2. Choose the created process assessment model,
3. Select the processes to be assessed,
4. Define projects,
5. Start assessment to assess the processes,
6. Assess each process one by one for each project:
   a) Enter findings and evidence,
   b) Rate practices and goals,
7. Choose all to merge projects,
8. Rate practices and goals,
9. Go to the "Analyze" step to see all the graphics,
10. Report the assessment:
    a) Enter Assessment Information,
    b) Organize Information.

During the automated assessment with GSPA, the tool expert observed the assessors and took notes. In addition, the assessor thought loudly for the expert to understand the thoughts of the assessor. Each assessment took approximately 2.5 hours. After the completion of the assessment they answered the questionnaire about their observation on the tool's capability, usability and suitability for the assessment.

After the assessment we asked the assessors to answer the following questions to understand their interpretations about the tool:

- Do you prefer automated process assessment rather than paper based process assessment? Why?
- What would the effort be if you performed paper-based assessment instead of automated process assessment? What percent does the effort change with the tool?
- What are the weaknesses and advantages of the tool?

Data Analysis: The qualitative data analysis was conducted for this study. It was based on content analysis, which facilitates the analysis of interview answers and observation notes. The content analysis is used to see the integrated and summarized way of the content of text or speech by transforming raw data into meaningful categories or themes to answer research questions[57].

4.3. Validity Threats

The person who observed the assessors during the assessment as a tool expert is the one who had developed the tool. Since there was a possibility of taking subjective notes during the observation, the results were reviewed and validated by the assessors for each case. This increased the internal validity. Furthermore, external validity is very important in order to generalize the results. Therefore, the sampling carries vital importance to represent the population. In this study, purposive sampling was used for determining the assessor and assessment cases. Even though one of the assessors was a student, he was familiar with the case and related model as explained in the case study conduct section. Furthermore, three cases were totally performed because of the availability of the assessors. However, each case was chosen to be heterogeneous so that all together it can represent all structured process assessment models.

5. Results

This chapter presents the findings and discusses the results for each case. The findings from the interviews, observations and questionnaires are presented in this chapter.

5.1. Assessment with ISO/IEC 15504

Case 1 included the definition of the "Quality Assurance" process elements (process purpose, outcomes, practices, work products, attributes) of ISO/IEC 15504 in the GSPA tool by the graduate student who had taken the Software Quality Management course at METU. Following that he used the tool to define assessment evidence, explanations, findings, organization information, ratings

[57] Y. Zhang, B.M. Wildemuth, *Qualitative Analysis of Content*, 2005, vol. 1(2), pp. 1–12.

for practices and goals. The following explanations are the results of the observation and think aloud process of the assessor:

The relationships between the outcome and achievement were established for necessary elements such as the base or generic practice. All elements of ISO/IEC 15504 could be added, edited or deleted. Both the capability dimension and process dimension were defined independently. In addition, the tool enabled to determine the capability level range.

All base practices and generic practices could be rated in ISO/IEC 15504. All the findings and observation notes were entered for each practice to the tool. In addition, the evidence was entered for each process attribute. Also, all the process attributes were rated.

There was detailed and summarized information about the assessment in the report. Furthermore, the ratings of practices and process attributes, entered evidence, and findings for each project were seen in the report. However, there was only one reporting template in the tool.

The tool provides guidance to an assessor with buttons and texts. The assessor could perform ISO/IEC 15504 assessment by following necessary steps. In addition, the tool supports the evaluation of different projects. Also, the different projects could be merged and a reasonable result could be obtained by combining the evaluation of different projects. However, there was no feature supporting parallel assessment in the tool.

It was easy to discover the feature of the tool while defining the process assessment model and performing the assessment. The buttons and descriptions helped the assessor use the properties of the tool.

The following explanations are the comments and impressions of the assessor from the interview:

He said that the information about ISO/IEC 15504 was provided systematically so that there was no time lost for searching the necessary elements. In addition, he mentioned that the effort was decreased with the tool because of its analysis and reporting feature. However, according to him, there was only one reporting template to obtain assessment results and the tool did not warn about the missing definitions.

5.2. Assessment with CMMI

Case 2 included the definition of the “Project Planning” and “Organizational Training” process areas elements (process area goals, practices, typical work products, practice elaborations) of CMMI in the GSPA tool by the assessor

who had been working intensively on process assessment related with CMMI and ISO/IEC 15504 for six years. Following that she used the tool to define the assessment evidence, explanations, findings, organization information, ratings for practices and goals. The following explanations are the results of the observation and think aloud process of the assessor:

The bottom and top level of CMMI capability dimension were determined with the tool. In addition, the generic goal, generic practice, specific practices were defined in the tool. However, the work products were associated with the generic goals instead of generic practices. Furthermore, both the capability dimension and process dimension were defined.

During the assessment, it was not possible to enter the evidence for each practice. Instead, the evidence was entered for only goals. Moreover, each goal and practice was rated. The findings were entered for each practice to the tool. While the generic goals were evaluated for each process area, she could not evaluate the generic goals as a whole.

CMMI evaluation results were seen as detailed and summarized in the report. Moreover, the ratings of generic practices and goals obtained from each project and findings and observation notes were seen in the report. The report contains everything including assessment input and organization information.

While defining CMMI, it was observed that there was no explanation about the maximum character for element abbreviation. Furthermore, there was no information about which elements are necessary for defining a process assessment model. However, the assessor understood which steps to follow and performed the assessment according to these steps.

In the tool, three different projects were defined for process assessment and the assessment was performed for each project. However, it was not possible to perform a parallel assessment since there was no feature about it. In terms of discovery of the tool features, the assessor did not face any problem. All the buttons and text areas were used when it was necessary.

The following explanations are the comments and impressions of the assessor from the interview:

The assessor mentioned that the data on the CMMI process assessment model were held systematically and assessment results were saved relationally. Furthermore, she said the reporting feature helped the assessor gain 20%–30% of her time. However, there was no evidence area for each practice and general area for assessing the generic goal.

5.3. The Assessment with the Agility Assessment Model

Case 3 included the definition of the "Exploration" and "Transaction" aspects elements (aspect outcome, attributes, work products, practices, and fallacies) of the Agility Assessment Model[58] in the GSPA tool by the assessor having three-year experience in CMMI assessment and being one of the creators of the Agility Assessment Model. Following that she used the tool to define the assessment evidence, explanations, findings, organization information, ratings for aspect practices and aspects. The following explanations are the results of the observation and think aloud process of the assessor:

All aspect attributes and practices could be rated with the help of the tool. Weaknesses and strengths could be entered for each aspect attributes. The evidence which was found during the assessment could be entered with type information to the tool. Notes and findings could be entered as text for each practice. However, there was no space to write everything during the assessment. Instead, the text areas for writing strengths or weaknesses were used for this purpose.

The results were demonstrated with graphics in a detailed and summarized way. Moreover, assessment inputs and organization information were seen properly in the report. The report also included notes and ratings regularly for each practice and aspect attribute.

While the tool allowed the definition of the elements in the Agility Assessment Model in a certain order, there was no explanation whether it was necessary to define the model element or not. In addition, the steps to be followed by the assessor were enumerated. However, there was no guidance if it was necessary to merge all the projects after entering the assessment findings for each project. The steps such as entering findings and evidence, entering and rating practices and aspect attributes were clearly understood and followed by the assessor.

Two different projects defined in the preparation step of the assessment were assessed separately and brought together and then the practices and aspect attributes were rated based on the evaluation of the two different projects. On the other hand, there was no feature to create an assessment team and allow different teams to perform the assessment.

The assessor faced some usability problems while using the tool. The definitions of the bottom and top level were not clear to determine the capability level range. In the tool, it was asked to determine which aspect attribute represents the process dimension and the assessor was expected to select one aspect

[58] Ö.Ö. Top, O. Demirörs, *Agility Assessment Model v1.0*, 2014.

attribute. However, this property was not understood by the assessor. The elements in the Agility Assessment Model were listed with their abbreviations but there was no explanation indicating that they were listed with their abbreviations. In addition, discovering the model creation feature at the beginning was a little bit difficult for the assessor since there was no tree view explaining the model structure in detail.

The following explanations are the comments and impressions of the assessor from the interview:

She pointed out that the assessment was performed easily because of the guidance feature of the tool. In addition, the access and regulation of the evidence was easier with the tool. She also stated that the reporting feature helped the assessor to gain 20%–25% of her time and the internal consistency of the Agility Assessment Model was measured with this tool. According to her, the compatibility with the structure of ISO/IEC 15504 was also checked with the tool. On the other hand, she said that the explanations and descriptions were not satisfactory enough. Moreover, she pointed out that there was no detailed tree view explaining the model structure and free text area while performing the assessment.

The following table shows the questionnaire results for each case on the sufficiency level of the tool in terms of the expected features.

Table 4. Feature Results

Feature/Process Assessment Model	Agility Assessment Model	ISO/IEC 15504	CMMI
The tool's suitability for defining a new model	**Fully Achieved**	**Fully Achieved**	**Fully Achieved**
Suitability for performing the assessment	**Fully Achieved**	**Fully Achieved**	Largely Achieved
Reporting automatically	**Fully Achieved**	Largely Achieved	**Fully Achieved**
Guiding the assessor	Largely Achieved	**Fully Achieved**	**Fully Achieved**
Evaluation of different projects	**Fully Achieved**	**Fully Achieved**	**Fully Achieved**
Suitability for a parallel assessment	Not Achieved	Not Achieved	Not Achieved
Suitability for the discovery of the tool features	Largely Achieved	**Fully Achieved**	**Fully Achieved**

Source: the authors' own work.

6. Discussion

In this section we provide the answers to research questions.

RQ1: To what extent is the tool sufficient in meeting the expected features?

As it is seen from Table 4, all the features except for the suitability of the tool for a parallel assessment are rated as "Fully Achieved" by at least two assessors. Especially, the main purpose of this study which is to create different process assessment models was met. This shows that our meta-model works good enough. In addition, the functionality of the tool is measured with the features which are suitable for performing basic assessment functions, reporting automatically, and the evaluation of different projects. The results, related with these features, show that the tool supports all kinds of process assessment models during an assessment in terms of functionality. Furthermore, guiding the assessor during the assessment and suitability of the tool for the discovery of the tool features are very important in terms of usability. While there are little problems for the process assessment models derived from ISO/IEC 15504 of CMMI, the tool can be used for CMMI and ISO/IEC 15504. The results of this study show that the tool meets the expected features almost completely for all the features expect for parallel assessment.

RQ 2: What are the advantages of an automated generic process assessment tool?

The multiple case study results show that the tool has the following advantages for process assessment. They are listed as:

- GSPA's features allow definition of new model components which were derived from either ISO/EC 15504 or CMMI.
- The internal consistency of derived process assessment models can be validated with this tool by matching each indicator such as a practice or work product with an outcome or achievement.
- The compatibility of a derived process assessment model to ISO/IEC 15504 or CMMI can be identified by comparing the model's concepts with the meta-model created by integrating ISO/IEC 15504 and CMMI.
- Since the information about the structured process assessment model is shown systematically, assessors do not lose time within the pages of technical report defining the process assessment model.
- The reporting feature helps assessors gain 20–25 percent of their time during a process assessment.

RQ 3: What are the weaknesses of the proposed tool?

The multiple case study demonstrated that the tool has some insufficient points However, the functionality of the tool is not deteriorated by these weaknesses. We summarize the weaknesses below:

- Extra elements such as fallacy cannot be defined as desired with the tool.
- Explanations and descriptions about determining the process dimension attribute and level satisfaction point, and merging projects are not satisfactory enough.
- There is no error control mechanism in the tool yet.
- The tool does not support parallel assessment yet.

7. Conclusion

In this study, GSPA – the generic software process assessment tool was proposed to support the process assessment based on various process assessment models. We evaluated the tool's sufficiency, usability and capability with a multiple case study.

GSPA is a software process assessment tool that supports definition of a new structured process assessment model based on ISO/IEC 15504 and CMMI structures, software process assessment, reporting of assessment results, guiding assessors during the process assessment, evaluation of different projects. The tool has also user friendly interfaces that allow the discovery of its features by the ones who are not familiar with the tool. GSPA shows the characteristics of an effective process assessment tool to support assessors in performing process improvement activities.

The study results show that the tool fulfills the requirements of the 6 of 7 expected features of a software process assessment tool satisfactorily since all the features except parallel assessment were evaluated or rated as fully achieved by the assessors. In addition, it has many advantages for process assessment in terms of gaining time, creating a process assessment model, validating a process assessment model, performing process assessment based on different process assessment models.

There are some weaknesses of the tool related with the definition of extra concepts, understandability of explanations and descriptions.

As the future research, we plan to conduct case studies during the process assessment in software organizations rather than assessing the tool over

assessment reports and perform an experimental study in order to compare paper-based assessment and tool supported assessment in real time situations. We believe that instant process assessment will introduce new challenges and move the capabilities of the tool a step further.

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