Comparison of Maturity Levels in CMMI-DEV and ISO/IEC 15504

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Abstract: - Although a classic staged maturity framework with 5 levels was introduced by W. S. Humphrey back in 1988, its basic ideas remain essentially unchanged and they are still employed in CMMI and other maturity models. ISO/IEC 15504, formerly known as SPICE, has promoted a continuous model for process capability assessment. Not long ago SPICE community recognized the benefits of a staged representation. As a result, the organizational maturity framework has been introduced in ISO/IEC 15504-7:2008. It should be noted that this new framework defines 6 maturity levels. This paper investigates relationship between CMMI-DEV and ISO/IEC 15504 maturity levels. It presents the mapping approach and correspondence of CMMI-DEV and ISO/IEC 15504 maturity levels.

Key-Words: - Software process, process assessment and improvement, organizational maturity, CMMI, ISO/IEC 15504, models mapping.

1 Introduction

Most software development projects face the following problems: projects are delayed; they overrun budget; and/or customers are dissatisfied with the quality of the software delivered. This phenomenon is so widespread that it is even being named as a software crisis [1]. It was understood that software process maturity is closely related to project success and quality of a software product. A successful project is defined as products delivered according on schedule, within budget, and meeting requirements.

Investigations in software process maturity provided a deep insight into software activities and introduced various software process models which helped assess and improve both software process capability and maturity of organization producing software. Organizations want to get all the advantages of different process models that stimulate their harmonization and investigation of process improvement in multimodel environments [2, 3].

The evolution of software process models has stabilized two main frameworks widely known as CMM and SPICE with their current revisions: CMMI and ISO/IEC 15504. These 2 models are prevalent and the most important worldwide [4, 5]. ISO/IEC 15504 is of an international standard and CMMI has become a standard "de facto. The same occurs in Lithuania. Software companies, as a rule, select CMM/CMMI [6, 7] when government supported projects promote ISO/IEC 15504 based models [8, 9].

Another reason for CMMI and ISO/IEC 15504 research relationships is that almost 10 years ago requirements for appraisal method according CMMI [10] had indicated the option of supporting the conduct of 15504-conformant appraisals but no such appraisal method has been published yet.

The purpose of this paper therefore is to investigate how the organizational maturity levels defined in these two models are related, i.e. what ISO/IEC 15504 maturity level is guaranteed by each CMMI maturity level and what CMMI maturity level is guaranteed by each ISO/IEC 15504 maturity level.

2 Background and Related Works

This chapter provides the key concepts of software process models and the motivation for the mapping between the models. The research performed is presented and explained in the next chapter.

A software process model defines the standard process that provides the basis for organization's process assessment and improvement. It should ensure the usage of the same concepts, relevance with the best software engineering practices and compatibility with internationally accepted standards.

Software process modeling examines two aspects: the activities of software product development or services provision; and the soundness of how well these activities' are performed, i.e. ability to meet the defined schedule, cost, scope, and quality goals.

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Software process models could have either a staged and/or continuous representation.

The staged representation model is designed to provide the assessment of the maturity of an entire software process (organization). It defines the stages (maturity levels) with each serving as a required foundation for the next one. The assessment result for the organization is a single rating (maturity level).

The continuous representation model is intended for the assessment of the capability of each named process (process area), such as requirements elicitation, software design, configuration management etc. In this case, the assessment result for the organization is the processes capability profile that consists of capability levels for each named process (process area). This approach allows the selection of a set of named processes (process areas) to be improved and the order of improvements that best meets an organization's business objectives.

Models of each representation have their own advantages. The criteria for which model should be employed should be carefully considered. The staged representation model is more suited for marketing purposes as it provides the single process maturity rating that is easy to advertise and to compare different organizations. However it is not detailed or flexible enough as it offers a solitary sequence of improvements. It also does not allow to measure software improvement in sufficient detail. This is particularly advantageous for organizations that have little or no experience in process improvement as this model provides guidance on the order of improvement. The continuous representation model provides enough detailed assessment on how well the organization's processes are performed. Although it allows the selection of its own methods of improvement, it is more complicated to compare the capability of different organizations.

All software process models summarize the best practices of software development and services worldwide. But although the source is almost the same, the resulting models are different. Therefore, organizations face the double problem of selection in that they will need to choose both the process model and the representation that is most suitable for their main goals. The solution is made further complicated because organizations want to benefit of the advantages of different models and the different representations. Therefore research that establishes the relationships between software process models and their different representations is important. Most investigations are devoted to the mapping of CMM/CMMI staged representation and SPICE/ISO 15504 continuous model as staged representation has been introduced in ISO 15504 only two years ago.

Each maturity level defines the set of key process areas to be performed. However, it is important to emphasize that this set of key process areas cannot be treated as true processes capability profile. This is because the processes performed could either be outside of the particular maturity level related activities or that some processes could have a higher capability level than required for the maturity level. Therefore, mapping of the maturity level defines minimal (necessary) processes profiles [11, 12].

An analysis of the conceptual relationship between two main software process assessment models CMM and SPICE is performed during their evolution [13, 14, 15, and 16]. Taxonomy and approaches for comparison of software process improvement models is provided in [17]. An attempt to integrate staged and continuous approaches in software process improvement is taken in [18].

The idea of establishing relations between maturity levels and processes capability profiles has been proposed in [19] that provides mapping of CMMI v. 1.1 staged representation to the draft of ISO/IEC 15504-2:1998. These relationships have been detailed in [20] by introducing achievement of capability levels expressed in grades and adjusting mapping of maturity levels 4 and 5.

The work [21] investigates relationships between continuous representation CMMI v. 1.1 and Measurement Framework defined in ISO/IEC 15504-2 and the Process Reference Model described in ISO/IEC 12207 Amd 1/2.

The current versions of the models have been investigated in [22] and the relationships between maturity levels of CMMI-DEV [23] and capability profiles of ISO/IEC 15504 [24, 25] have been established.

Recently ISO/IEC 15504 has also introduced maturity levels [26] and this paper presents their relations with CMMI-DEV maturity levels.

3 Models mapping approach

A brief discussion and presentation is provided so as to understand the mapping of the models' structure.

CMMI staged representation [23] is based on classic staged maturity framework that was introduced by W. S. Humphrey in 1988 [27]. It defines 5 maturity levels: from initial (level 1) to optimizing (level 5). Each of the maturity levels (except maturity level 1) comprises a number of process areas which collectively ensures manageability and predictability of the organization process and forms a base for the next process

improvement stage. The rating elements in the CMMI are the specific and generic goals; however, the rating of goals is performed on the basis of evidence recorded against each specific and generic practice. Therefore, the practices are "indicators" of process performance and process capability.

ISO/IEC 15504, former SPICE, has always promoted a continuous model for process capability assessment. However, not long ago SPICE community has recognized the benefits of staged representation. As a result, the organizational maturity framework was recently introduced in ISO/IEC 15504-7:2008. It should be noted that instead of classic 5 maturity levels this new framework defines 6 levels: from immature (level 0) to optimizing (level 5). Each of the maturity levels (except maturity level 0) comprises the defined process capability profile. So for the determination of an organization's maturity level, its process capability profile should first be obtained.

The same steps should be performed for mapping maturity levels: first, process capability profile corresponding maturity level should be determined then this profile should be transformed into a maturity level.

ISO/IEC 15504 model has 2 dimensions. The process dimension consists of processes and each process is defined in terms of its purpose and outcomes (i.e. results of the successful implementation of the process). Capability dimension defines 6 capability levels: from incomplete process (level 0) to optimizing process (level 5). Each capability level (except level 0) has the set of process attributes (PA) that define the particular aspects of process capability. The process attributes are defined by stating the achievements to be implemented. The process attribute of level 1 (PA1.1) requires special consideration because its single achievement is related to the outcomes defined for the process. The achievement of this attribute is measured in terms of process outcomes. Consequently, the mapping should address for each process the "process outcomes" (for level 1) and the "achievements" (for levels 2-5).

So, the specific and generic practices of CMMI process areas are mapped into outcomes and achievements of ISO/IEC 15504 processes.

Such a mapping scheme has been used in [19, 20]. It should be noted that mapping of such enough high level elements leaves too much leeway for personal judgment. Therefore, more detailed elements of the models have been examined as candidates for mapping.

Although subpractices in CMMI are informative components meant only to provide ideas that may be used for process improvement, they provide guidance for interpreting specific or generic practices. Therefore, CMMI subpractices have been included into mapping, the same as in [21]. Additionally typical work products and generic practice elaborations have been included in the mapping. An organization's processes assessment conformant ISO/IEC 15504 is based on a Process Assessment Model (PAM). Thus it has been decided to employ into mapping an exemplar PAM defined in ISO/IEC 15504-5 [25]. It expands the process definitions by including a set of base practices that serve as process performance indicators. PAM also defines a second set of indicators of process performance by associating work products with each process. The capability dimension, defined in ISO/IEC 15504-2 [24], is expanded with generic practices, generic resource indicators, and generic work product indicators. All these models elements have been included in the presented mapping.

The results of CCMI-DEV maturity levels mapping to ISO/IEC 15504 process capability profiles have been discussed in [22]. This paper presents the ISO/IEC 15504 maturity levels assured by CMMI-DEV maturity levels and reverse mapping results. The relationship between maturity levels assumes an implication: if an organization possesses maturity level N in one model, then the maturity level in another model of this organization is not "lower" than established by the mapping presented.

4 ISO/IEC 15504 Maturity Levels Assured by CMMI-DEV

As it is described in the previous chapter, mapping for each CMMI-DEV maturity level has been done by the following steps:

- Informative CMMI elements of process areas assigned to this maturity level are mapped into ISO/IEC 15504-5 process indicators;
- Mappings obtained are summarized at traditional mapping level: CMMI specific and generic practices into ISO/IEC 15504 process outcomes and achievements;
- ISO/IEC 15504 Processes Attributes (PA) rates in percents are calculated;
- Process capability is expressed in grades (N – Not performed, P – Partially, L – Largely, F – Fully);
- ISO/IEC 15504 process capability profile is established;
- ISO/IEC 15504-7 organizational maturity level assured by CMMI-DEV maturity level is determined.

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The results of the mapping are presented in Figure 1. ML2 - ML5 are CMMI-DEV maturity levels. CL1 - CL3 are ISO/IEC 15504 capability levels. Bold frames show the minimum process capability profiles required for corresponding ISO/IEC 15504 maturity levels.

Although models mapping is not able to provide the exact ISO/IEC 15504 maturity level for an organization the CMMI assessment results can be translated into ISO/IEC 15504 assessment data so avoiding full reassessment.

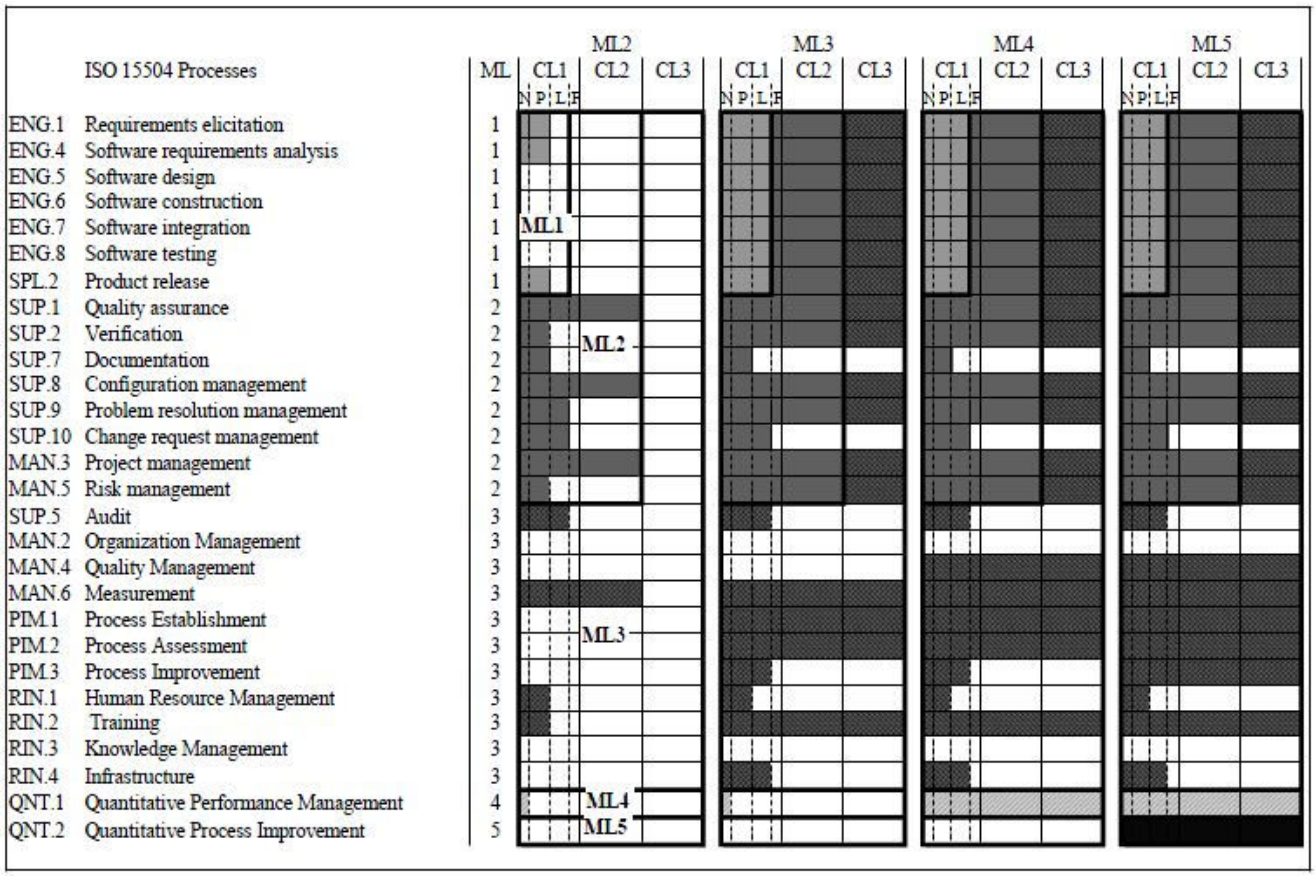

Fig. 1. ISO/IEC 15504 maturity levels coverage by CMMI-DEV maturity levels

CMMI-DEV maturity level 2 only partially addresses 3 of 7 processes forming ISO/IEC 15504 maturity level 1. So CMMI level 2 organization could be immature (level 0) according ISO/IEC 15504. It can be noted that CMMI ML2 includes the processes of support and management categories only, while ISO/IEC 15504 ML1 consists of the processes of support and engineering categories. This indicates a gap in staged CMMI based process improvement. The process improvement path should explicitly include primary (engineering) processes from the beginning.

CMMI-DEV maturity level 3 addresses the processes of engineering, management and support categories. Thus all 7 processes forming ISO/IEC 15504 maturity level 1 get capability level 3 (when only CL1 is required for ML1). ICO/IEC 15504 maturity level 2 adds 8 processes of a basic process set and requires all its processes to be performed at capability level 2. All these processes are already addressed by CMMI ML2 but even CMMI ML3 does not assure capability level 2 for all of them: Change request management gets CL1 when Documentation gets CL0. So CMMI level 3 organization has ISO/IEC 15504 basic maturity level (level 1).

Unfortunately **CMMI-DEV maturity levels 4 and 5** do not cover more outcomes of ISO/IEC 15504 maturity level 2 because they do not include the processes of the support category. Therefore they can only assure ISO/IEC 15504 basic maturity level (level 1) for an organization.

The mapping results show that the ISO/IEC 15504 scope is wider than CMMI-DEV that does not include organization management and knowledge management practices.

Audit, infrastructure, documentation, and human resource management processes are weakly addressed in CMMI-DEV: first two processes get CL1 only when the other two do not satisfy even CL1 requirements.

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5 CMMI Maturity Levels Assured by ISO/IEC 15504

ISO/IEC 15504 mapping to CMMI approach is the same but mapping is performed in the reverse direction. A process area is rated Satisfied, if all of its specific and generic goals are characterized as either Largely Implemented or Fully Implemented.

The results of the mapping are presented in Figure 2.

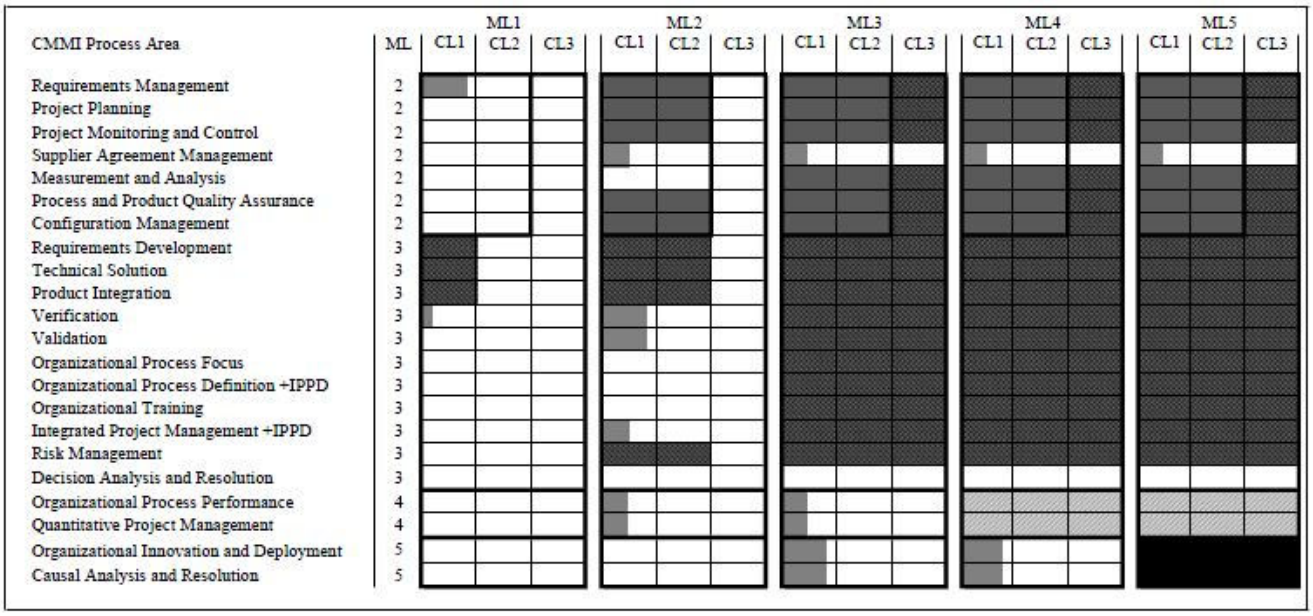

Fig. 2. CMMI-DEV maturity levels coverage by ISO/IEC 15504 maturity levels

ISO/IEC 15504 maturity level 1 addresses only 1 of 7 process areas assigned to CMMI-DEV maturity level 2. So ISO/IEC 15504 level 1 organization could get level 0 according CMMI. ISO/IEC 15504 ML1 assures capability level 1 for 3 engineering process areas but they are assigned to level 3 in CMMI.

ISO/IEC 15504 maturity level 2 does not assure CMMI-DEV maturity level higher than 0 because the Measurement and Analysis process area is not addressed at all. It could be noted that process areas Organizational Process Performance and Quantitative Project Management are already partially covered.

ISO/IEC 15504 maturity level 3 is treated as assuring CMMI-DEV maturity level 2 because according CMMI appraisal method [28] Supplier Agreement Management is the only process area that may be designated as not applicable. The mapping shows an evident gap in ISO/IEC 15504 process dimension: The Decision Analysis and Resolution is not included. It should be noted that the new process model presented in ISO/IEC 12207:2008 already has a Decision Management Process. So, we assume that updated ISO/IEC 15504 will include this process and its maturity level 3 will guarantee CMMI ML3.

ISO/IEC 15504 maturity levels 4 and 5 assure only CMMI-DEV maturity level 2 because of the same reason. But adding of Decision Management Process will allow them to assure CMMI-DEV maturity levels 4 and 5 correspondingly.

6 Conclusions

This paper contributes to the software process assessment and improvement theory and practice by:

- establishing ISO/IEC 15504 maturity levels assured by CMMI-DEV 1.2 maturity levels;
- establishing CMMI-DEV 1.2 maturity levels assured by ISO/IEC 15504 maturity levels;
- supporting the development of method for organization assessment results according one model translation into assessment results according other model.

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