Mapping CMMI-DEV Maturity Levels to ISO/IEC 15504 Capability Profiles

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Abstract: - CMMI and ISO/IEC 15504 are two main models for software process assessment and improvement. CMMI staged representation provides the standard way to process improvement and the attractive simple measure for organization's software process maturity. ISO/IEC 15504 ensures the possibility to assess the capability of each process, to get the detailed organization's processes capability profile and to define an individual improvement path. This paper investigates relationship between CMMI-DEV maturity levels and ISO/IEC 15504 processes capability. The mapping approach and ISO/IEC 15504 processes capability profiles ensured by all CMMI maturity levels are presented.

Key-Words: - Software process assessment and improvement, organization's maturity, processes capability profile, CMMI, ISO/IEC 15504.

1 Introduction

Almost forty years ago the software development situation was named as software crisis so indicating sore problems with budget, schedule, and quality. Almost twenty years ago it was understood that there is no silver bullet for the solving of software related problems [1] and the research emphasis was shifted to organizational and methodological matters.

Software process engineering is accepted as a most achieved software engineering area during last decade. Investigations in software process maturity allowed to get deep insight into software activities, define management of a software process, define quality of a software product through the quality of a software process, and introduce sound software process models helping assess and evaluate both software process and organization.

The research achievements are noticeable but the problems of the software projects are still very actual and sharp. Organizations seek to benefit from different process models that stimulate harmonization of different models and investigation of process improvement in multimodel environments [2, 3].

Software process evolution has raised two main frameworks widely known as CMM and SPICE with their current revisions: CMMI and ISO/IEC 15504. These 2 models are prevalent and most important worldwide [4, 5]. The same confirms the situation in Lithuania: software companies ourselves as a rule select CMM/CMMI [6, 7] when government supported projects promote ISO/IEC 15504 based models [8, 9].

One more reason for research relationships between CMMI and ISO/IEC 15504 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.

Purpose of this paper is investigation how these two models are related, i.e. how CMMI maturity levels can be expressed by ISO/IEC 15504 processes capability profiles?

2 Background and Related Works

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

Software process model serves as a foundation for the process definition, assessment and improvement. It should assure 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 these activities' characteristics that describe how sound they are performed, i.e. ability to meet the defined schedule, cost, scope, and quality goals.

All software process models could be classified according to their architecture (representation) into staged and continuous.

The staged representation model is intended for the assessment of the maturity of entire software process and it defines five stages (maturity levels) of sequential process improvement. The assessment result for the organization is a single rating (maturity level) that allows comparisons among organizations.

The continuous representation model is intended for the assessment of the capabilities of each named process (process area), such as requirements elicitation, software design, configuration management, and etc. In this case, the assessment result for the organization is the processes capability profile consisting of capability levels for each named process (process area) so identifying most straggle named processes. Though the capability of each process is assessed separately but this does not mean that processes are not related to each other and it is not possible to improve one process without improving associated processes.

There is no unequivocal answer which software process model architecture is more suitable. The criteria of model particularity and purposes of its application should be employed. The staged representation model is more suitable for the marketing purposes because it provides for the organization a single rating that is enough evident for its potential customers and it is easy to compare process maturity of the different organizations but it is not enough detailed and flexible because it offers a solitary sequence of improvements and does not allow to measure software improvement in more detail. The continuous representation model allows selection of the order for process improvement that best meets the business objectives of the organization but is more complicated to compare the maturity of different organizations.

The organizations should choose the process assessment model more suitable to their main goal but it is desirable to benefit of advantages of both models. The possibility to view the real software process in the organization from both perspectives – continuous and staged – is important but complicated task.

Each maturity level defines the set of key process areas to be performed. But it is important to emphasize that this set of the key process areas cannot be treated as true processes profile because an organization performs its own primary processes depending on basic activity that can be outside of the particular maturity level related activities. Therefore, mapping of the maturity level defines minimal (necessary) processes profile [11, 12]. The relationship between CMMI maturity level and ISO/IEC 15504 processes capability profile assumes an implication: if an organization possesses maturity level N, then processes capability profile of such organization is not "lower" than established by mapping the models.

Analysis of 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 version 1.1 staged representation to draft version of ISO/IEC 15504-2:1998. These relationships have been detailed in [20] by introducing achievement of capability levels expressed in grades (N – Not performed, P – Partially, L – Largely, F – Fully) as real assessment and adjusting mapping of maturity levels 4 and 5.

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

This paper presents relations between maturity levels and capability profiles of the models current revisions: Capability Maturity Model Integration for Development (CMMI-DEV) [22] and ISO/IEC 15504 Information Technology – Process Assessment [23, 24].

3 Maturity Levels and Corresponding Capability Profiles

For understanding of the mapping the structure of the models is shortly discussed and mapping approach is presented.

ISO/IEC 15504 assessment model has 2 dimensions. 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 (of course, 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 with the outcomes defined for the process: 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).

CMMI staged representation defines 5 maturity levels to measure the process capability of an organization: from initial (level 1) to optimizing (level 5). Each of the maturity levels (except for maturity level 1) comprises a number of process areas which collectively ensures current stage of manageability and predictability of the organization process and form a plateau 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 in the terms of ISO 15504.

So, the specific and generic practices of CMMI process areas are mapped into outcomes and achievements of ISO/IEC 15504 processes. Simplified structure of the models, including only elements addressed in mapping, and the traditional mapping scheme are presented in the Figure 1.

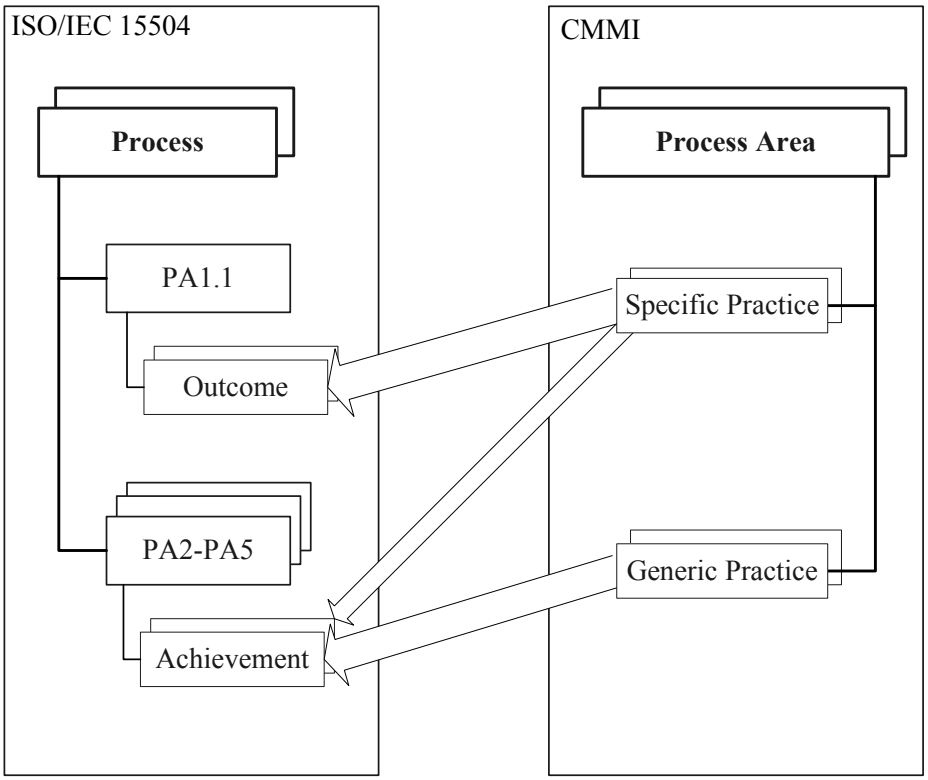

Fig. 1. Simplified structure of the models and traditional mapping scheme

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

Although subpractices in CMMI are an informative components meant only to provide ideas that may or may not 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. Organization's processes assessment conformant ISO/IEC 15504 is based on Process Assessment Model (PAM). Thus it has been decided to employ into mapping an exemplar PAM defined in ISO/IEC 15504-5 [24]. 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 [23], is expanded with generic practices that belong to a set of indicators of process capability, in association with generic resource

indicators, and generic work product indicators. All these models elements have been included in the mapping presented.

As a result the following mapping approach has been established:

- Informative CMMI elements are mapped into ISO/IEC 15504-5 process indicators;
- Mappings obtained are summarized at traditional mapping scheme: 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 levels are expressed also in grades using the scale: up to 15 % – N (Not performed/achieved), more than 15 % and up to 50 % – P (Partial), more than 50 % and up to 85 % – L (Large), and F (Full performance/achievement) for more than 85 %.

The resulting ISO/IEC 15504 processes capability profiles corresponding to CMMI maturity levels are presented in Figure 2: "ML2"- "ML5" are the maturity levels in the CMMI-DEV staged representation and "CL1"-"CL5" are capability levels in ISO/IEC 15504.

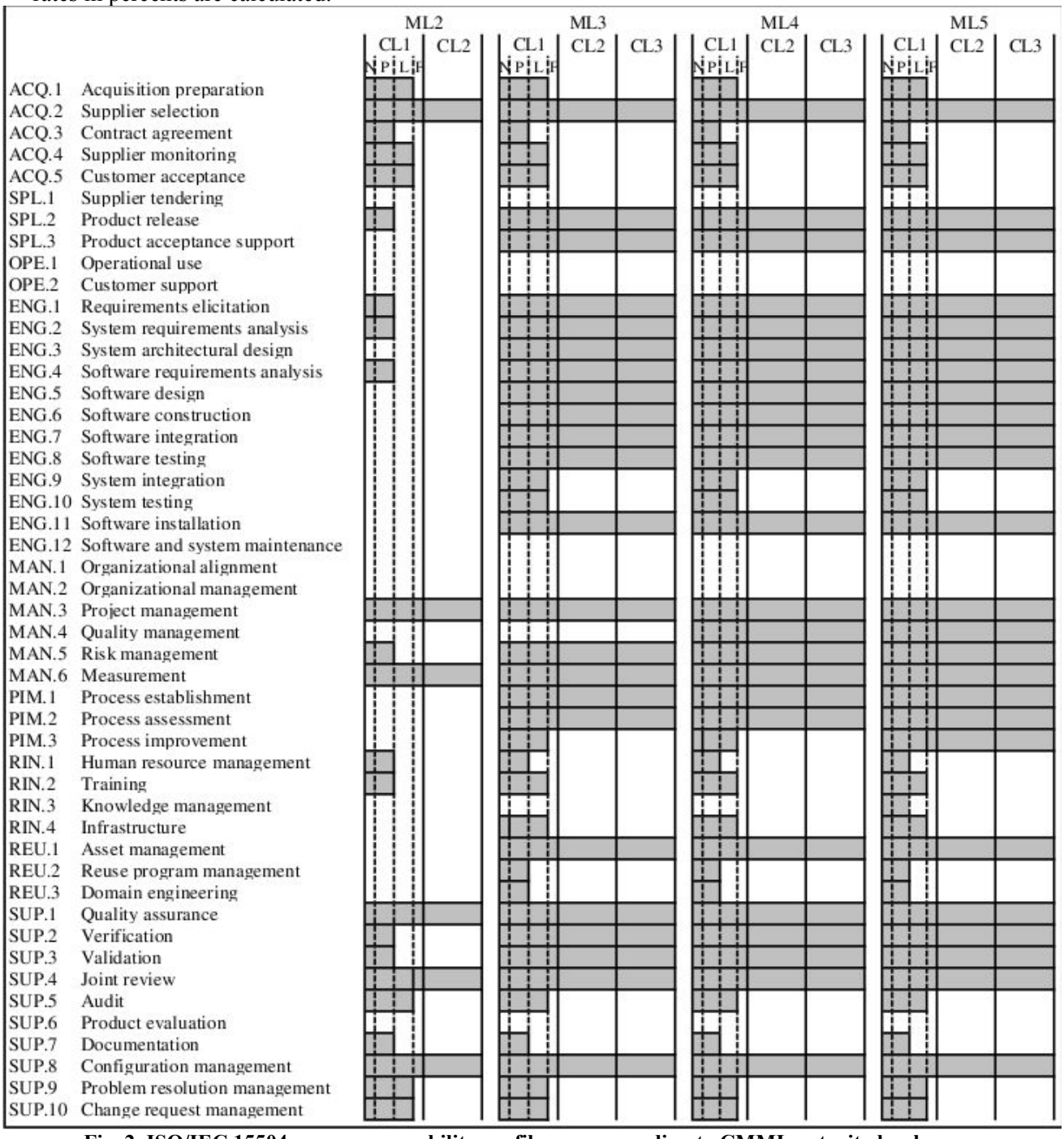

Fig. 2. ISO/IEC 15504 processes capability profiles corresponding to CMMI maturity levels

Established relationship between CMMI-DEV and ISO/IEC 15504 allows to state that if an organization is CMMI, for instance, level 2 organization then ISO/IEC 15504 processes capability profile of such organization will contain processes capability "maturity level 2" profile. These profiles should be treated as minimal ones, i.e. processes of the particular maturity level organization will have capability levels not lower than in the corresponding profile obtained by models mapping.

Although models mapping is not able to provide the exact ISO/IEC 15504 processes capability profile for an organization the CMMI assessment results can be used and translated into ISO/IEC 15504 assessment to avoid full reassessment.

Table 1. PA ratings for capability levels

Level	Process Attributes	Rating
1	PA 1.1. Process performance	L or F
2	PA 1.1	F
	PA 2.1 Performance management	L or F
	PA 2.2 Work product management	L or F
3	PA 1.1, PA 2.1, PA 2.2	F
	PA 3.1 Process definition	L or F
	PA 3.2 Process deployment	L or F
4	PA 1.1, PA 2.1, PA 2.2	F
	PA 3.1, PA 3.2	F
	PA 4.1 Process measurement	L or F
	PA 4.2 Process control	L or F
5	PA 1.1, PA 2.1, PA 2.2	F
	PA 3.1, PA 3.2, PA 4.1, PA 4.2	F
	PA 5.1 Process innovation	L or F
	PA 5.2 Continuous optimization	L or F

3.1 Capability profile for maturity level 2

Processes capability profile ML2 consists of 6 processes of capability level 2 and 6 processes of capability level 1. Also 12 processes are partially addressed. Ratings of process attributes required for capability levels are presented in table 1.

It can be noticed that this capability profile includes the processes of support and management categories only. This indicates the gap or too big step in staged CMMI based process improvement. The process improvement path should explicitly include primary processes from the beginning. Such element is absent in staged CMMI improvement path – primary processes are outside of the scope of maturity level 2.

It seems that this minimal capability profile is not only necessary but also sufficient condition for maturity level 2. However, this issue requires explicit investigation to evaluate the influence of CMMI maturity level 2 items not covered in ISO/IEC 15504 model.

3.2 Capability profile for maturity level 3

Specific practices of maturity level 3 key process areas cover some outcomes of new processes in ISO/IEC 15504 process dimension and supplement outcomes of processes (partially) covered by specific practices of maturity level 2 key process areas.

Maturity level 3 in the staged CMMI suppose performance at this level (generic goals of maturity level 3) key process areas of both maturity levels – level 2 and 3. Generic practices of maturity level 3 ensure full coverage of attribute PA3.1. But process attribute PA3.2 is achieved by specific practices mostly.

As a result processes capability profile ML3 consists of 23 processes of capability level 3 and 11 processes of capability level 1.

3.3 Capability profiles for maturity levels 4 and 5

Processes capability profile ML4 additionally includes Quality management (MAN.4) process and ML5 - Process improvement (PIM.3) process also.

It is important to note that CMMI does not require capability level 4 and 5 for all process areas. This means that set of processes performed at capability level 4 and 5 can be introduced by organization depending on its activity and business goals.

4 Conclusions

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

- establishing detailed ISO/IEC 15504 processes capability profiles for CMMI-DEV 1.2 maturity levels;
- supporting the development of method for organization assessment results according CMMI translation into assessment results according ISO/IEC 15504.

Further investigation could be oriented to:

- Definition of minimal processes capability profiles ensuring each CMMI maturity level;
- Method for translation of organization assessment results according the models of different architecture.

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