Supporting Audits and Assessments in Multi-model Environments

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Abstract. Software development organizations are adopting multiple improvement technologies to guide improvement efforts. A recent trend is the simultaneous adoption of CMMI and ISO models into a single environment originating multi-model process solutions. Some of these models address similar areas of concern and share similar quality goals. Reusing organizational implemented practices is an opportunity to establishing compliance with multiple models and reduce implementation costs.

Audits and assessments can take advantage of practices reuse if information characterizing similarities between quality goals of different models is maintained. This paper proposes a conceptual model to support management of quality goals information in support of multi-model audits and assessments.
An example is described of applying the proposed model in supporting the generation of data collection checklists to perform, in a single effort, a multi-model audit process. The conceptual model is being applied in a Portuguese software house with a multi-model process solution compliant with several improvement technologies.

Keywords: Multimodel Environments, Software Process Audits, Process Assessment, Software Process Improvement.

1 Introduction

Software organizations are adopting several improvement technologies to improve their overall performance. Improvement technologies is used in this paper as shorthand for reference models, quality standards, best practices or any type of practice based improvement technology. Adoption of these improvement technologies is driven by several reasons, namely: market pressure, the need to comply with regulations and performance improvement. A multi-model process solution results from adopting several improvement technologies into a single organizational environment. A recurrent combination is the simultaneous adoption of the best practice model CMMI-DEV [1] and the ISO9001 standard [2] into a single environment, originating a multi-model process solution.

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Some improvement technologies often address similar domains of concern defining similar expected practices and outcomes (hereafter referred as quality requirements). In a recent study the authors concluded that an high level of shared scope exists between improvement technologies frequently adopted in the software domain [3]. When this is the case, implementing practices to assure compliance with shared quality requirements is an opportunity to reduce costs of implementing multiple improvement technologies (hereafter also referred as quality models).

A related concern is that quality models change and evolve. As result organizations inevitably need to change their practices by adopting new or dropping obsolete practices. Evolution is a natural result of new releases of quality models, changes in regulatory requirements or even the decision to address new markets, which require market specific practices. In a managerial prescriptive, assuring traceability between implemented practices and quality requirements is a good practice, it assures that changes are traced back to implemented practices and manage the potential impact. However, assuring this type of alignment and, at the same time, take advantage of shared scope between adopted quality requirements is not straightforward. It requires identifying similarities between quality requirements and then manage how implemented practices related to quality requirements. An ad-hoc approach is prone to inefficiencies that can jeopardize compliance objectives and cost effective implementations of multiple models.

Thus, an approach is needed to help improvement groups in assuring traceability between multiple quality models and manage their change and evolution. Organizations in these scenarios are left with the challenge of assuring traceability of implemented practices with quality requirements from different quality models and manage information related to shared scope between quality requirements.

Siviy et.al. introduced the concept of harmonization in response to some challenges identified in multi-model environments [4]. A harmonization framework is outlined describing the general steps needed to choose, compose and implement multiple quality models. Specifically, one of the opportunities identified in harmonizing multiple quality models is to optimize costs in audits and assessments for operational units and projects. This paper addresses this issue considering that, if quality models share scope of concern, implemented practices and resulting outcomes can be used to establish compliance with multiple quality models. Audits and assessments will benefit from systematizing this information with the purpose of, in a single effort, collecting evidence to evaluate compliance to multiple quality models implementation.

The paper is organized as follows: Section 2 discuses related work in the area of harmonization and multi-model comparison and composition. Section 3 analyses background information related to assessment, audits and appraisals, and describes relevant considerations in the process of mapping models. Section 4 proposes a conceptual model to systemize information relevant to support multi-model audits and assessments. Section 5 describes an example of applying the proposed model and Section 6 concludes and outlines future work.

2 Related Work

Multi-model environments challenges and opportunities were documented by Siviy et.al. in [4]. Competition between improvement initiatives using several improvement technologies, when implemented separately, becomes costly and benefits are eroded

when compared to benefits of single efforts. Harmonization is introduced as a general approach to align different model into a single environment by means of a harmonization framework composed of four steps: 1) alignment of organizational and improvement objectives and identify improvement technologies, 2) categorize improvement technologies strategically, 3) design the improvement solution and 4) implement the multi-model solution and measure results.

One recurrent technique applied in multi-model scenarios is the model mapping technique. It is used to compare quality models with the purpose of finding associations between quality models by using a mapping function. Model mappings can be used, in the harmonization context, in support of selection and composition of quality models. The semantic associated to the mapping function determines the type of model comparison and composition. In recent literature, the most recurrent type of comparison, involves comparing model in terms of purpose and expected outcomes, also denominated *what/what* comparisons and named as *degree of relation* or *support* in [5] or *mapping confidence* in [6] and characterizes the amount of shared scope between models. Examples of these mapping exercises are provided by Pino et.al in [7-9].

In [10], Siviy *et.al*. identify tactical combinations between Six Sigma and CMMI-Dev 1.2 (hereafter shortened to CMMI). Elements of each considered improvement approach are compared and mapped to identify possible tactical combinations to drive process improvement. The semantics of the mapping function is now centered in identifying synergies between elements of process improvement initiatives, also denominated *what/how* combinations. The focus is on finding similarities in addressable scope by identifying synergies between improvement approaches.

Audits and assessments in multi-model environments will benefit from identifying similarities concerning purpose and expected outcomes of considered quality models. The model mapping technique can be used to obtain this type of information. To our knowledge, previous research has not considered how information on identified shared scope between quality requirements can be operationalized to support multi-model audits and assessments. That is the subject of this research work.

3 Multi-model Audits and Assessments

When organizations adopt a quality model, practices and requirements are interpreted according to organizational specific context and needs. Organizational specific practices are implemented aligned with adopted quality models. If a more formal approach is used to define organizational practices, e.g., to satisfy CMMI maturity level 3 goals, practices definitions need to be formalized using process models and/or process modeling languages, e.g., SPEM (Software & Systems Process Engineering Metamodel Specification version 2.0) [11] specification provides relevant process concepts for process definition. The result is an OSSP (Organizational Set of Standard Processes) that provides a collection of process and practices definitions to be enacted by the organization. From this set, project or organizational units define specific processes considering tailoring guidelines if applicable.

When organizations adopt several quality models, the sequence of model adoption becomes an issue that must be considered. One may choose a first model for adoption,

carry out an implementation of the chosen model and then choose a second model for implementation, following the implementation of the first model. Other possibility is to choose more than one model and plan a joint implementation. When adopting more than one quality model, harmonizing is beneficial to improve efficiency of joint implementations [4]. Harmonizing focuses on finding possible similarities and synergies of chosen models to facilitate and improve efficiency of joint implementations.

Multi-model environments will benefit from an explicit step for harmonizing models before practices are incorporated in the organizational environment. Fig. 1 depicts a high level interpretation (not exhaustive on concerns related to harmonization) of the harmonization framework introduced by Siviy *et.al.* in [12].

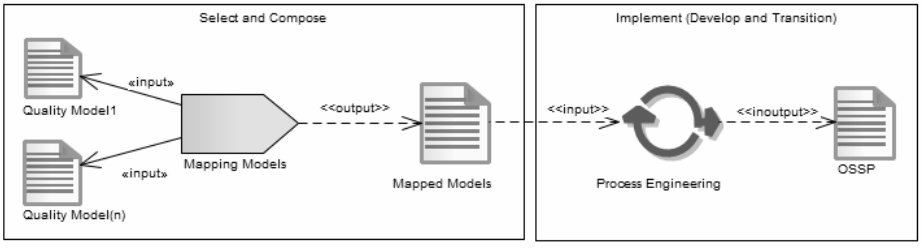

Fig. 1. High level process supporting harmonization

In the *Select and Compose* phase a *Mapping Models* task produces a mapping table by receiving as input different quality models. Quality requirements from considered quality models are compared and a mapping table is produced. The mapping table can be used as input to an engineering process to support development of a multi-model process solution. In *the Implement (Develop and Transition)* step, similarities and difference are identified and used to design practices and associated outputs alighted with harmonized quality requirements.

In designing our approach to support multi-model audits and assessments we considered the model mapping technique and the organizational scenario where an OSSP exists, providing detailed definitions on how the organization processes should be performed. This means the sequence in Fig. 1 has completed at least one iteration. The motivation to consider such scenario is twofold: first, although model mappings are subjective in nature, we considered publically available mappings by Mutafelija and Stromberg [13] [14] has a good example in identifying shared scope between ISO and CMMI quality models, due to their level of detail and completeness of comparison. The second reason is the fact research is being carried out in the context of a Portuguese software house with a multi-model process solution. Critical Software S.A. that recently achieved a CMMI maturity level 5 rating and complies with standards like ISO9001, Aerospace Standards 9100 and 9006 and ISO12207[15]. Our approach is based on the following assumptions: a mapping between quality models that considers shared scope as the semantic associated to the mapping function can provide a first level guidance on identifying possible reuse points for joint audits and/or assessments. Further, if an OSSP provides the necessary detail on how practices should be performed and these practices are aligned with one or more quality models, OSSP elements can be reused to improve efficiency of data collection tasks facilitating the implementation of audits and/assessments on a single effort.

The following subsections detail concerns related to model mappings and some considerations regarding audits, assessments and appraisals that will support the design of our conceptual model.

3.1 Model Mappings Considerations and Implications

One purpose of a model mapping exercise is to find similarities and differences between a pair of improvement technologies. A mapping involves pairs of models and a mapping function that relates entities of both models to deliver a mapping result. A mapping result is a set of relations categorized by the mapping function between every entity of one model to every entity of the second model. When mapping models, differences in structure need be considered to produce the mapping e.g., CMMI defines specific practices within process areas, ISO12207 uses activities and tasks and ISO 9001 uses shall statements. We are not considering a specific mapping between models so we abstract these structural differences and refer to them as quality requirements.

When executing a mapping with objective of providing support to joint audits and assessments, the following considerations assume central relevance:

1) A quality requirement from a quality model can share a "*scope of concern*" with one or more quality requirements from other models. The degree of the sharing or similarity can be characterized quantitatively or qualitative, e.g., a CMMI practice can share, with different degrees of similarity, scope with several ISO9001 shall statements. In practice, the mapping defines how much of one quality requirement when implemented can be re-used to support the implementation of a mapped quality requirement
2) The degree of similarity of scope between quality requirements of different models is not reflexive (*à priori)* – e.g., stating that a CMMI practice is related in a certain degree to an ISO 9001 shall statement is not the same as stating the mentioned ISO9001 shall statement is related to the CMMI practice in the same degree. This fact has been also mentioned in [7].

The first consideration assumes that a relation can be established between quality requirements to characterize the degree of shared scope. Whatever the scale used for characterizing the degree of relationship, the semantic associated should be how related are intended purpose and expected outcomes of compared quality requirements (product or service), e.g., the contents of the output can be used as evidence to demonstrate, partially or totally, the fulfillment of the compared quality requirement.

Fig. 2 depicts this relation where a quality requirement can be related to multiple quality requirements from different origins and each relation is characterized by a coverage value that translates the aforementioned semantic. The mapping between quality requirements defines dependencies between quality requirements, allowing identifying possible reuse points for evidence collection.

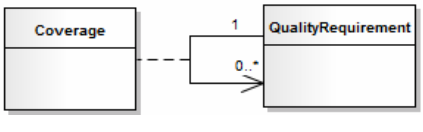

Fig. 2. Coverage between quality requirements

The second consideration states the self-association *(Coverage) in* Fig. 2 is not reflexive. This is a direct result of the type of semantic associated with the considered mapping. When relating a quality requirement to a second quality requirement from a different model and analyzing the degree of similarity of the intended output, one needs to consider that one quality requirement is fully implemented and compare how it relates to the mapped quality requirement, e.g., when comparing a CMMI specific practice purpose and expected output, one may assert that, if fully implemented, it can be used as evidence to satisfy an ISO 9001 shall statement. In this case CMMI assumes the role of reference model and ISO 9001 as the mapped model. The degree of similarity is characterized as the amount of reuse of the output of the CMMI implemented practice is expected to provide to satisfy the compared ISO 9001 shall statement.

When comparing quality requirements to identify shared scope the following scenarios may occur: in Fig. 3, the first Venn diagram from the left shows how a mapped requirement (transparent circle) can be partially (70 out of 100) covered by using a subset of the outcome of a reference quality requirement (grey circle).

The second from the left represents an example where full coverage is attained but the reference requirement can be said more extent in the scope it defines. The third diagram represents an example where the comparison can be considered reflexive; the scopes are similar and the outcomes are similar. Therefore, association between two requirements cannot be considered bi-directional *à priori* and is defined as unidirectional in Fig. 2. In the fourth Venn diagram no scope is shared between quality requirements.

When defining mappings to support a joint audit and/or assessments, choosing a quality model that provides the most detailed and most alighted requirements with organizational business needs may be considered a logical decision, e.g., a software company may consider CMMI as the reference model and ISO 9001 and ISO12207 as secondary models. Thus, the mapping should be established using as reference model CMMI and ISO9001 and ISO12207 as mapped models.

Fig. 3. Quality requirements mappings

3.2 Tracing Quality Requirements to Implemented Practices

Audits and assessments require objective evidence to establish conformance of implemented practices with reference standards, regulations, plans, specifications and capability frameworks and other relevant reference guidelines. Objective evidence is any result or byproduct of implementation or institutionalization of practices. Objective evidence is mentioned in ISO1028 IEEE Standard for Software Reviews and Audits [16], Standard CMMI Appraisal Method for Process Improvement [17] and ISO15504-2 - Process assessment [18] to represent any relevant work product that may be used to evaluate conformance.

In the previous section we discussed that quality requirements provide guidance for defining and implementing needed organizational practices. We also considered that quality requirements from different models may be compared by relating their expected outcomes and characterize then according their degree of similarity. This section discusses how implemented practices can be linked back to quality requirements for the purpose of supporting audits and assessments in multi-model environments.

According to IEEE Standard 1028 [18] the purpose of a software audit is to provide an independent evaluation of conformance of software products and processes to applicable regulations, standards, guidelines, plans, specifications, and procedures. Concerning evidence collection for evaluation purposes, the standard makes reference to interviews, examination of documents and witnessing processes as means to gather objective evidence of non-conformance or exemplary conformance. Audit observations are documented based on these objective evidence and are classified as major or minor. It does not provide any detail on how and where objective evidence should be looked for.

According to ISO 15504 [16] process assessments have two primary contexts for their use: process improvement and process capability determination. Process assessments aim to find strengths, weaknesses and risks inherent to processes providing drivers for improvement of processes. Process capability is determined by analyzing organizational processes against a capability profile. A capability profile is based on a measurement framework that defines a set of attributes that characterize the capability of a process to fulfill its goals.

Three entities are relevant in performing process assessments:

- A *measurement framework* provides the capability profile and is used to derive a capability rating.
- *A process reference model* or models e.g., CMMI or ISO 12207, provide the necessary process descriptions that will be used as frame of reference for organizational practices capability determination.
- An *assessment model* defines elements to relate processes of the process reference model(s) chosen as reference and the measurement framework process attributes to produce a capability rating. According to ISO 15504-5 - An exemplar Process Assessment Model, elements of the assessment model can be indicators of performance and capability.

A process assessment model forms a basis for the collection of evidence and rating of process capability. It requires to establish a mapping between organizational processes to be assessed and the process reference model(s) process definitions [16]. ISO15504-2 refers to the suitability of a process model as a function of the degree of focus of assessment model indicators on observable aspects of process enactment and the assessment model degree of alignment with relevant process reference model [19].

An *appraisal* is defined as an examination of one or more processes using as reference an appraisal reference model as a basis for determining, as a minimum, strengths and weaknesses [17]. It can be considered a type of assessment if it is performed internally by the organization. One underpin of the SCAMPI (Standard CMMI Appraisal Method for Process Improvement) appraisal method is the link between CMMI process goals and implemented organizational practices. Goals are

satisfied by gathering objective evidence of each generic and specific practice implementation. Objective evidence is expected to be from different types e.g., oral affirmations must be collected to support objective evidence concerning practices implementation. The SCAMPI method defines the concept of practice implementation indicator to support the evaluation of practices implementation. A practice is considered implemented when direct artifacts, indirect artifacts and affirmation are gathered that provide substantiate evidence of practices implementation. Direct and indirect artifacts can be documents and affirmations are oral or written statements that result from interviews presentation or demonstrations.

Based on the analysis of audits and assessments approaches the concept of indicator and the concept objective evidence assume a central importance. Indicators are an abstract representation to group objective evidence of organizational practices implementation and establish the association between performed processes and measurement attributes, if a capability assessment is to be performed. Also, affirmations are obtained manly from interviews and are required to substantiate and provide objective evidence of implemented practices. Based on this highlighted concepts, the next section elaborates on a model that relates relevant entities in support of multi-model audits and assessments.

4 Multi-model Audits and Assessments

As discussed in the previous sections, quality requirements of different model can be related by the amount of shared scope. Purpose and expected outcomes are compared to characterize their degree of similarity. Quality requirements also provide motivation and guidance to define organizational practices. Those are interpreted considering organizational context and needs to define the most adequate set of practices in achieving desired business goals.

In the context of multi-model environments, performing an evaluation of areas of concern related to different quality models in a single audit or assessment can reduce costs and improve efficiency of audits and assessments. e.g., in a single exercise evaluate process compliance to ISO12207 and CMMI by reusing collected evidence. In order to reuse collected evidence one needs to identify which artifacts are shared among different quality requirements. This is possible by defining maps between organizational practices and quality requirements, allowing to list artifacts relevant to a specific quality requirement implementation. By considering coverage associations between quality requirements it allows identify which artifacts can be shared among related quality requirements.

The meta-model in Fig. 4 introduces relevant entities and how these relate to each other in support of audits and assessments in multi-model environment. A *QualityRequirement* is associated to zero or more *QualityRequirement* entities of different origin, e.g., one can map an ISO9001 shall statement to several CMMI specific practices. The association between quality requirements is set by *Coverage* association, defining the degree of shared scope between *QualityRequirement* instances. As an example, in a mapping between ISO9001 and CMMI , an ISO shall statement, *Establish QMS,* maps to 29 specific practices of CMMI with different coverage values, defined by a scale of comparison that can assume values of 0,30,60,100.

Considering that a formal definition of organizational practices is provided, e.g., an OSSP describing with detail performed practices and expected artifacts, one can use this information and establish an association between quality requirements and artifacts defined in the OSSP. An *Artifact* refers to any tangible process element used to describe or maintain process related information, e.g., an artifact can be a Work Product Definition, Task Definition and other process constructs if e.g., SPEM specification is used as a modeling language to define an OSSP.

An *Indicator* is used to group relevant process related artifacts defined in the OSSP, which are expected to provide objective evidence of quality requirements implementation. This step requires that a mapping between artifacts and related quality requirements is established, e.g., in support of specific practices of CMMI process areas, a set of relevant work products and task descriptions are identified that are expected to provide evidence of practice implementation, when these are enacted by project or organizational units.

With mappings established between OSSP artifacts and quality requirements with coverage associations between quality requirements defined, artifacts used as evidence for a quality requirement implementation can be reused also as evidence for mapped quality requirements, e.g., artifacts associated with CMMI specific practices implementation can be reused to provide objective evidence of ISO9001 shall statements which are mapped to CMMI specific practices.

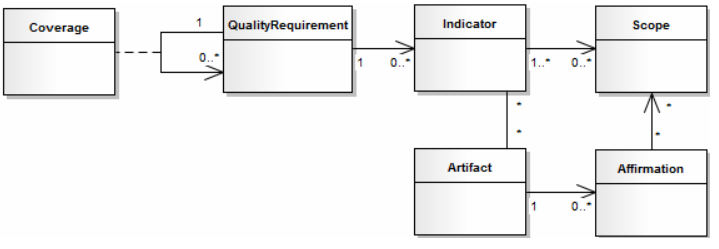

Fig. 4. Traceability between quality requirements and implemented practices

Both audit and assessment standards make reference to the need of having supporting oral of performed practices from practice implementers. The element *Affirmation* is associated to *Artifact* to emphasize that artifacts require oral or written statements as supporting objective evidence. An affirmation is a type of objective evidence to confirm artifact related evidence. An *Affirmation* instance is expected mainly as result of interviews when assessments and audits are performed.

The proposed model includes the concept of *Scope* to make explicit the notion that audit and assessment may consider different scopes. A *Scope* instance has always an associated *Indicator* instance which is always associated to a *Quality Requirement* instance. By choosing relevant quality requirements from different quality models, associated indicators are automatically identifiable, whether these are obtained directly by the *Indicator/QualityRequirement* association or indirectly by the Coverage association defined between *QualityRequirement* instances.

An *Affirmation* instance can be associated to multiple scopes. This allows defining different affirmation instances related to a same artifact, providing flexibility in defining different elements to support collection of oral or written statements for different scope scenarios.

Fig. 5 depicts an example of a generic joint multi-model audit scenario based in the perspective of the model proposed in Fig. 4. The two left columns depict six quality requirements (QR) considered for a desired scope (not shown in the diagram). The first column represents mapped quality requirements and the second column represents quality requirements from a reference model. Coverage (C) associations are established between selected quality requirements. The quality requirements in the second column have associated indicators (I) defined. Each indicator results from identifying relevant artifacts (A) that are expected to provide objective evidence of implemented practices. Indicators are represented in the third column with associated artifacts. It is possible to verify that different indicators may reuse artifacts as evidence for different quality requirements implementation. This is possible as it depends how practices and expected outcomes are implemented in the organizational environment.

From the mappings defined between quality requirements it is possible to identify QR(1), QR(2) and QR(3) from the mapped model have coverage associations defined to QR(4) and QR(5) of the reference model, respectively. Five coverage associations are defined with values of C(100), C(100), C(100) and C(60). The notation C(X) is used to describe the *Coverage* association instead of an actual object to simplify the object diagram. QR(1) and QR(2) can reuse artifacts from indicators I1 and I2 of QR(4) and QR(5) respectively. QR(3) has only a portion of reused scope with QR(5) and requires an indicator (I3) that identifies the set of artifacts to assure full compliance coverage of QR(3).

The fourth column represents affirmations instances associated to artifacts for each indicator. Questions are a possible type of affirmations that can be defined and maintained by internal quality teams or process improvement groups, to use in obtaining required oral or written statements as support of objective evidence, e.g., obtain statements if a work product or activity description is implemented as expected.

In support of software audits, the model in Fig. 4 can be used to define multiple audit scenarios, e.g., in performing project or process audits one may define different types of audits and chose different scopes for each type. The scope of the audit is defined by identifying relevant indicators which are associated to quality requirements from multiple quality models. Question can be maintained as instances of affirmation which can be associated to multiple different scopes

In the specific context of assessments and using as example the assessment model proposed in ISO 15504-5 [19], an assessment model indicator is refined into performance and capability indicators. We opted to not include this level of refinement in the conceptual model by considering that it depends on the method defined for the assessment model. By considering solely the concept of indicator we leave the possibility of extending the concept of indicator to support possible different assessment methods, e.g., by considering different measurement frameworks and associated capability indicators.

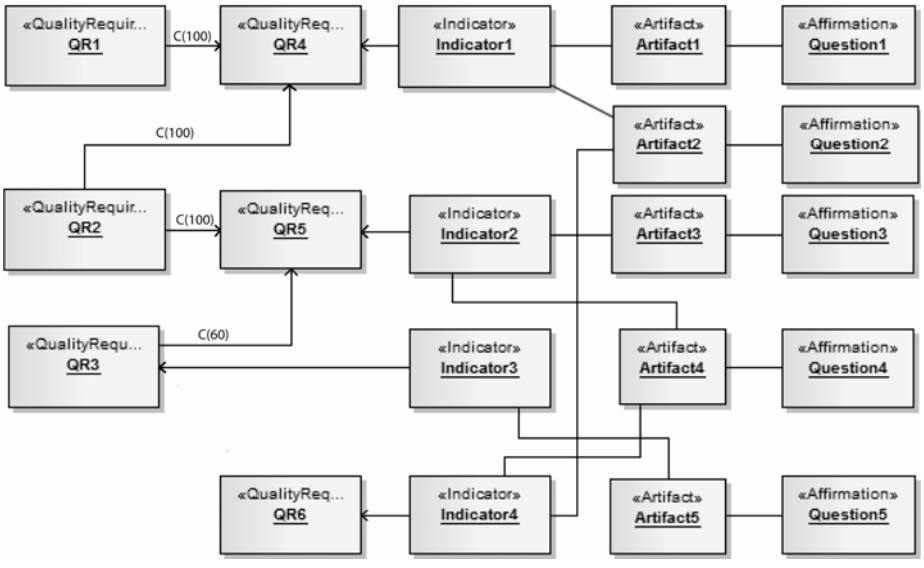

Fig. 5. Generic joint audit or assessment scenario

5 Multi-model Process Audit Example

This section details the use of the conceptual model presented in the previous section in support of a joint audit exercise. An organizational scenario is provided to describe how it can be applied. ISO12207, ISO9001 and CMMI are considered to exemplify a multi-model process environment and highlight the benefits of considering models similarities in support of multi-model audits.

The model presented can be used in the context of QM (Quality Management) activities and in the scope of Audit Process activities. In the scope of a QM process one expects to identify possible similarities between quality models and then proceed to identifying which OSSP process assets can be used in the process of determining compliance with considered quality models. Fig. 6 depicts example QM related tasks of *Model Mapping* and *OSSP and QR mapping* defined using SPEM 2.0 notation. The output of the *Model Mapping* task are mapping tables where quality requirements from different quality models are mapped and a coverage function is used to characterize their relationship, considering their similarity in terms of purpose and outcomes. To perform this task one needs to determine one of the quality models as the reference model. By choosing a reference quality model the direction of the relationship for the mapping function is determined. As an example CMMI will be considered as the reference model and ISO12207 and ISO9001 the mapped models. The mappings between ISO12207 and ISO9001 to CMMI in [13, 14] provide output examples of the *Model Mapping* task for this type of scenario.

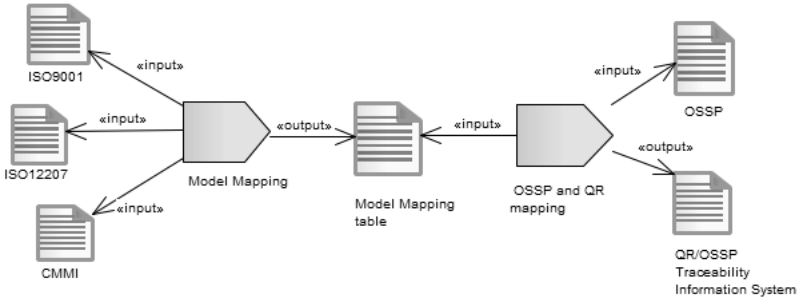

Fig. 6. Quality Management process

The resulting mapping tables are used as input to *OSSP and QR mapping* task along with process definition related information. The expected output is an information system based on the conceptual model described in the previous section.

The *OSSP and QR mapping* task includes the following steps:

1) The mapping tables are used to create *QualityRequirement* and *Coverage* instances. First, all specific practices of CMMI, ISO12207 activity and tasks and ISO9001 shall statements originate a *QualityRequirement* instance. The mappings resulting from the previous task are used to define *Coverage* instances between *QualityRequirement* instances.
2) For all *QualityRequirement* instances of the model considered as reference, an *Indicator* instance is defined by identifying relevant *Artifacts* in the OSSP, e.g., if SPEM is used as process modeling language to define the OSSP, SPEM constructs like *Task Definition*, *WorkProduct Definition*, *Activity,* among others, can be used as instances of type *Artifact* to define indicators for each specific practice of CMMI.
3) For all remaining *QualityRequirement* instances, not belonging to the reference model, an analysis is required to evaluate if *QualityRequirement* related instances (defined by a *Coverage* instance) do include all relevant artifacts in the OSSP that can be useful in supporting desired compliance. This is a vital point in the process of mapping quality requirements with OSSP process entities. It allows reusing most of information regarding mapped quality requirements and takes full advantage of shared scope between adopted models. If mapped quality requirements do not provide full coverage, additional indicator instances need to be defined identifying missing relevant OSSP artifacts, e.g., if an ISO12207 activity is fully covered by related CMMI specific practices it can reuse artifacts identified by the indicators associated to CMMI specific practices and still require extra artifacts to support full compliance for the activity considered.

Fig. 7 depicts an example (not exhaustive) of a QR/OSSP Traceability Information System, describing associations on shared scope between quality requirements and OSSP process related entities. The first and second columns represent quality requirements from ISO9001 and ISO12207 respectively, along with their coverage association with CMMI practices, which are represented in the third column.

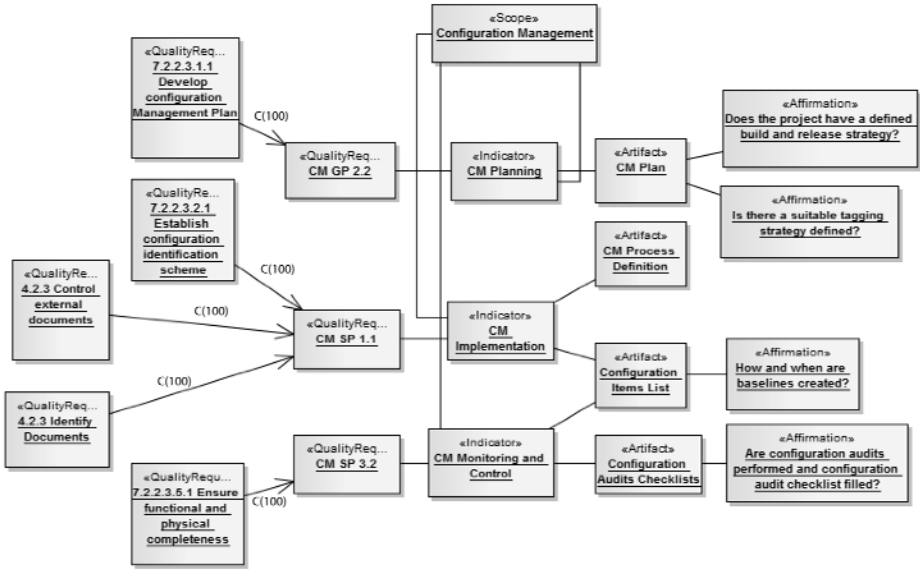

Fig. 7. QR/OSSP Traceability Information System example

The QR/OSSP Traceability Information System can be used to support the joint model audit process. As an example, an audit scope can be defined to include, among others, evaluation of CM (Configuration Management) process area of CMMI and CM process from ISO12207. Checking the mapping table in [14] used to originate *QR and the QR/OSSP Traceability Information System*, (see Fig. 6) it is possible to check that all ISO 12207 CM activities and tasks have full coverage by CMMI CM specific practices. Indicators defined to support CMMI CM practices data collection could be reused to guide data collection for compliance with ISO12207 CM process. Within a scope set to include CM practices from CMMI and ISO12207 an audit checklist template for data collection can be easily defined in an audit planning task. The checklist is defined by selecting the *Configuration Management* Scope, which lists the audit questions and expected artifacts that could provide evidence of practices implementation (see Fig. 7).

Further, to optimize the audit process, questions can be added by internal auditors concerning a specific scope to help gathering objective evidence on performed practices. These questions become instances of type *Affirmation*, which become associated to artifacts of the OSSP and the scope defined for a specific type of audit or assessment. This association allows defining different questions for different scopes relative to a same artifact. By maintaining information regarding *Scope* and *Affirmation* instances it becomes simple to manage data collection checklists in support of multi-model audits and/or assessments.

This section provided a small example on how joint audits can be performed reusing most of the effort of evidence collection. In [3] a quantitative evaluation is performed based on the mappings considered for this example that allowing to conclude that ISO9001 and ISO12207 share with CMMI 83% and 74% of their scope

respectively. This provides a measure on the amount of effort that could be optimized when performing full compliance evaluations for multiple quality models. Our conceptual model is designed to dispose information concerning shared scope between quality requirements and how, in the presence of OSSP formal definition, process related artifacts are being used in support of QRs implementation. By maintaining information aligned with the proposed conceptual model, one can improve quality management activities in multi-model environments by:

- Precisely identify which OSSP related artifacts are involved in quality requirements implementation.
- Define indicators that operationalize the information related to shared scope between quality requirements from different quality models.
- Identify which quality requirements are affected by possible changes in process related artifacts.
- Identify which organizational practices can be dismissed by dropping specific quality requirements
- In the context of a project enactment system based on OSSP definitions, project audits and capability assessments can be partially automated. This is possible by monitoring process enactment of by collecting objective evidence of performed practices.

6 Conclusions

In this paper a conceptual model to support management of information related to quality requirements of multiple improvement technologies was presented. The main goal is to support audits and assessments of multiple improvement technologies in a single effort. The underlining motivation is that different improvement technologies often share scope of concern providing the opportunity to reuse evidences of organizational practices implementation in evaluating compliance to multiple quality models.

The proposed conceptual model is based on the model mapping technique and in the concept of performance indicator. The mapping is used to compare quality requirements from different improvement technologies and evaluate their degree of similarity concerning purpose and expected outcomes. The concept of indicator is used to group organizational process entities involved in quality requirements implementation, which can be used to guide the collection of objective evidence of their execution.

The model aims to help improve internal quality management capability in managing multi-model internal audits and assessments. An external multi-model certification scheme is impossible as certification bodies yet do not acknowledge certifications from other certification bodies.

A small example of using the concepts introduced in this paper is provided to exemplify how the model can be useful in providing support to a joint process audit considering ISO9001, ISO12207 and CMMI. The conceptual model is currently being implemented in a Portuguese software house, Critical Software S.A., with the objective to improving the efficiency of conducting project and organizational audits. A series of experiments are in progress to further validate the proposed model.

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