Unified Quality Training Process

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Abstract: The development of quality in the global market has made standards and repository indispensable tools. Each standard has its own strengths and covers specific perimeters in the company, which necessitates the co-deployment of several standards simultaneously. However, the diversity of standards can lead to different problems such as heterogeneity and redundancy, which results in increased implementation costs in terms of time, resource mobilization and budget. We propose a quality approach called *"Unified Quality"* to address these problems. This paper describes the configuration process that creates The common repository, that encompasses all requirements of the co-deployed standards without redundancy and ambiguity. It is an iterative and MDE based process. Finally, the training process is illustrated by its application to both ISO 9001 and CMMI standards.

1 INTRODUCTION

Quality development is a key competition process in the global market. This requires companies to use standards and benchmarks of good practices in management and information systems. Several standards cover the main activities of IT (information technology) systems such as ISO 9001 (Marques et al., 2017), CMMI (noa, 2015) and ITIL (noa, 2012). Each standard has its own strengths but does not satisfy the collection of IT system requirements independently of other standards (Jomaa, 2015). For example, ITIL ensures the post-production quality, while CMMI improves the maturity level of company's software engineering processes. However, ITIL or CMMI cannot satisfy, by its self, the whole company needs.

The problem remains in the implementation of several standards within the same company. Several works have attempted to approach this subject. Some authors believe that this issue is due to heterogeneity of standards that it is manifested in their entities and their processes structures (Muñoz et al., 2014)(Kerzazi, 2015), It can also appear in terms of terminology, size or complexity level (Pardo-Calvache et al., 2015)(Dahar and Roudies, b). For instance, heterogeneity causes difficulties for organizations in interpreting components of several standards (Pardo et al., 2015)(Pardo et al., 2012). while for others, the issue is related to redundancies that generate additional costs in terms of human resources, time and budget (Baldassarre et al., 2012).

Many types of approaches have addressed the challenges resulting from the co-deployment of several quality standards, namely:

- Ontological approaches that present ontologies (Pardo et al., 2012) and Baldassar (Baldassarre et al., 2012) to overcome the problem of terminological difference in standards.
- Approaches based on model engineering and construction of a general meta-model (Ponce et al., 2014) which is based on the Meta models of standards.
- Approaches of integrating (Marques et al., 2017) one model into another, or into a common framework adopted by the organization.

Our literature review shows that these approaches are specific and focus on managing two or three well-defined standards. We therefore conclude that research field is lacking of an approach not limited to a little number of standards. In other words, we need an approach that allows to align a set of undefined and unlimited standards.

Trying to remedy the inefficiency of the simultaneous use of several standards, we propose Unified Quality approach. It is supported by the MDE (Model Driven Engineering) approach. It aims to align several standards in order to facilitate their integration and to minimize the efforts related to their simultaneous usage in the IT field. In addition, it optimizes audit process.

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Our approach consists of two processes: Configuration and Audit. The approach's configuration process aims to integrate several standards into the same optimal quality repository. The standards are integrated in an incremental way, which capitalizes on the building of the quality repository and its training. The configuration process is divided into two sub-processes for this purpose:

- First, the building the pivot meta-model that presents the structure of the quality repository.
- Second, the training process of this repository.

This repository allows to unify different structures of the quality standards in order to solve their heterogeneity and redundancy issues. The second process of Unified Quality approach is devoted to the quality audit of a specific organization. First, the organization chooses the collection of standards it wishes to co-deploy. Then, Unified Quality system provides a set of elementary requirements that the auditor has to check. These are represent all the chosen standards in a clear and not redundant manner. The audit process will be addressed in subsequent study.

This paper is devoted to training process. Building the pivot Meta Model has been described previously. The objective of this paper is to describe how a new adopted standard is integrated in the quality repository and how the requirements are optimised.

To validate our approach, we apply it to ISO 9001 and CMMI to ensure the functioning of the proposed models and transformations. We choose the ISO 9001 case that is already integrated in the quality repository and consider the integration of the CMMI model.

The rest of the paper is organized as follows. The second section is a overview of different aspects of the article, the third section summarizes the construction process of the pivot meta-model, the fourth one describes the training process of Unified Quality approach, followed by the fifth section that describes the experiment of the approach application. Lastly the conclusion highlights the strengths of this approach, some limits and leads to new perspectives.

2 UNIFIED QUALITY OVERVIEW

Unified Quality consists of two processes: Configuration and Audit.

2.1 Configuration Process

The configuration process presents the backbone of the UQ approach. Its main objective is to unify the standards chosen by the company into a single repository called the UQ repository, and this to facilitate and optimize the simultaneous use of the standards within the company and to eliminate the problems caused by this issue. To this end, UQ repository contains all the requirements of integrated standards. These requirements are grouped by sector and are elementary and unique. The configuration process is subdivided into two sub-processes, namely, building of the pivot meta-model sub-process entitled UQ pivot building and the training sub-process entitled TPUQ.

- UQ-Pivot Building Process: UQ Pivot meta-model is a meta-model that supports communication between standards and the UQ repository. It presents the structure of the UQ repository on which the training process is based. The process occurs only once in the life cycle of the system, except in future need.
- Training Process: the role of this process is to train the new standard in the UQ repository. It is an iterative process. The number of iterations equals the number of standards to be integrated. It is flexible and dynamic, depending on the standard.

2.2 Audit Process

The second process of Unified Quality approach is devoted to the quality audit of a specific organization. First, the organization chooses collection of standards it wishes to co-deploy. Then Unified Quality system provides a set of elementary requirements that the auditor has to check. These represent all the chosen standards in a clear and not redundant manner. The audit process will be addressed in subsequent work.

We propose in the following a detailed description of each sub-process composing the configuration process, to present on the one hand their phases, steps and tasks and explain on the other hand their concepts and theoretical foundations.

3 PIVOT META-MODEL

Our goal is to analyze the structures and concepts of existing standards in order to build a common model. It aims to align the structures of quality standards in order to facilitate their communication and minimize the efforts related to their simultaneous use. For this purpose, we follow an MDE approach. We rely on Meta modeling to deduce the final structure of the model. In our approach, we call the common model **UQ pivot model** and its meta-model **UQ pivot meta-model**.

This section describes the **UQ pivot meta-model**. The details of the process of this meta-model building are given in a previous article(Dahar et al.,)(Dahar and Roudies, a).

Figure 1 presents the UQ pivot meta-model. The UQ pivot meta-model consists of the Standard class . Each standard is composed of a set of rubrics. It allows the standard to be subdivided into several areas or specialties. In addition, the requirements underline the need to be met in order to obtain certification of a standard.

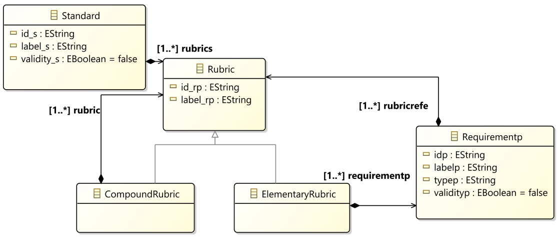

Figure 1: Pivot meta-model.

- Requirement: After analysis of the concepts of the standards leaders, we noticed that in the standards, the main concept is Requirement for ISO9001 and Practice for CMMI. These two concepts have the same intention at the level of organizations, it presents the action or need to be satisfied in order to obtain the level of quality required.
- Rubric: In addition, the other classes of the two standards generally allow the grouping of these requirements according to one or several axis. Therefore, there are two types of rubrics, elementary and compound rubrics.
- Compound Rubric: The grouping contains groups of requirements in order to have a well-structured hierarchy, for example Composite item for ISO 9001 and Process area for CMMI.
- Elementary Rubric: The grouping of requirements is directly linked to the requirements, for example objective for CMMI and elementary article for ISO 9001.

4 TRAINING PROCESS

UQ Training is an agile process. It allows to unify standards in a UQ repository. This repository eliminates misunderstanding and redundancy in the requirements of standards, and inconsistency in their structures. The process integrates the standards into the UQ repository incrementally. It consists of three phases: the loading phase of the new standard, the refinement phase and the integration phase. It relies on the quality engineer who is a required analyst, and his main role is to make sure that the products comply with the company's requirements, and to manage the balance between productivity and quality. In this process, he is in charge of judging the elementary and refining. The figure shows the steps and tasks of the training process as well as their input and output models. Figure2

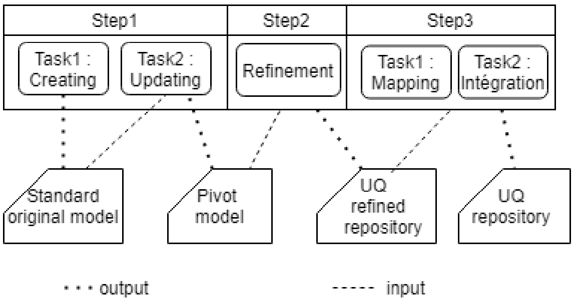

Figure 2: UQ training process.

4.1 Step 1. Loading a New Standard

The standard loading step consists of studying each standard separately. It is based on model engineering. Its goal is to load the new standard into the UQ pivot model. As explained above, the main actor is the software engineer. This step consists of two tasks. The first one is the loading of the standard original model and the second one is its transformation into UQ pivot model.

4.1.1 Task 1. Creation of a Standard Original Model

It consists of representing the new standard by a model based on the standards concept. For example CMMI is represented in terms of processes areas, goals and practices. The result is the standard original model. This standard original model is related only to the standard, so it is the same model regardless of the enterprise. Thus, it is maybe reused. This step is usually carried out by the quality engineer of the enterprise.

4.1.2 Task 2. Updating UQ Pivot Model

The original model of each standard is transform in order to express in the UQ pivot Model. UQ pivot model encompasses the representation of each selected standard expressed by common language. For example CMMI is expressed in the pivot model in terms of requirements and rubrics as shown in figure1. This perform by defining transformation rules.

Our method uses a (1 to 1) transformation (Mens et al.,). The transformation system used is said to be exogenous because the source and target models do not come from the same metal-model. This system is also called horizontal because the source and target models involved in the transformation are at the same level of abstraction. The transformation mechanism used to load the UQ pivot model is schematized in Figure 3.

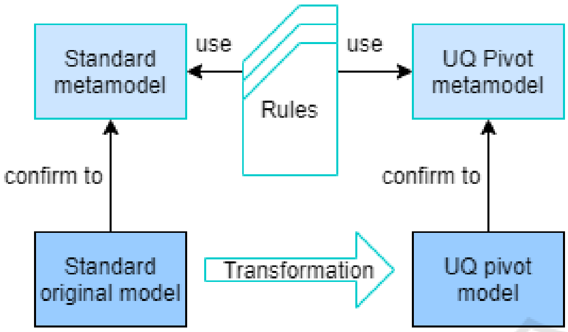

Figure 3: Transformation from standard to Pivot repository.

4.2 Step 2. Refinement of a Standard

Before analyzing the correspondence between requirements of the UQ pivot model and those of the UQ repository, it is necessary to ensure that they are placed at the same level of granularity. In this phase, we use an analytical approach based on requirements engineering. The requirements of the quality standards are functional. They define one or more functionalities to be applied. The proposed solution to unify the level of granularity is the function-oriented refinement. The goal is to rewrite a requirement into several refined requirements. A refined requirement is elementary, associated with a single functionality. The refinement is done by the quality engineer. The latter is in charge of analyzing requirements, defining their functionalities and rewriting them into elementary requirements.

Given

RP : The set of UQ pivot model requirements.

RR : The set of refined requirements.

r $\in RP$ and $r_i \in RR$.

We express this refinement by the function named "F" presented by two equations; Equation 1 is defined from RP to RR^n. Indeed, if r is an elementary requirement then it is assumed to be already refined. Therefore the image of r is the same. Otherwise, we decompose r into several elementary requirements r_i. The union of r_i is equivalent to r, as illustrated in Equation 2.

$$F(r) = \begin{cases} r, r \text{ is elementary} \\ (r_1, r_2, r_3, , r_n), \text{otherwise} \end{cases} \quad (1)$$

$$\cup_{i=1}^{n} r_i \iff r \quad (2)$$

4.3 Step 3. Construction of the UQ Repository

This step is composed of two main tasks.

4.3.1 Task 1. Requirement Mapping

In this phase, we create mapping links between the refined requirements and the UQ repository requirements. This is done by the company's quality engineer. Analyzing each repository requirement with each UQ pivot model requirement is a long and cumbersome process. We define two levels of mapping, namely rubrics and requirements. At the first level, we analyze the mapping between the rubrics of the UQ pivot model and those of UQ repository. This allows us to identify the rubrics that cover similar areas or that may have points of intersection and also those that cover completely separate areas. This level allows us to detect all requirements that will be analyzed at the second level. It is obvious that there is no mapping link between requirements that belong to divergent rubrics, and only those that belong to aligned rubrics will be analyzed.

The function RM represented the requirements mapping takes the following values:

- 1 in the case where there is a mapping,
- 0 otherwise.

The function RQM The function RM represented the rubrics mapping takes the following values:

- 1 in the case where there is a mapping,
- 0 otherwise.

Many Natural Language Processing (NLP) applications allow to compute the similarity in meaning between two short texts. There is a wide range of methods for calculating the similarity in meaning between two sentences like Pre-trained sentence encoder(Cer et al.,) and Smooth Inverse Frequency(Karipbayeva et al.,) or more advanced algorithms like Siamese Manhattan(Amin et al.,).

These methods can be used to automate the comparison of two requirements and to estimate the error distance at the equivalent level. The quality engineer will intervene only if the error distance is low in order to confirm the equivalence between the two compared requirements. The comparison of the efficiency of each similarity algorithm and the implementation of the most relevant one remains to be studied as part of my future work.

4.3.2 Task 2. Merging the Standard and the UQ Repository

This composition makes it possible to merge the requirements of two models by taking into account the mapping links established between these requirements. And this for ensuring that these requirements are not duplicated in the new UQ repository. In addition to the final model of the UQ repository.

The requirements of the source models are divided into two main groups. The first group presents those that have a mapping in the model opposite, while the second group presents those that do not. Indeed, there are two activities that produce elements in the target model which is the UQ repository. The elements that have been identified as mapping are merged into a sequence of model elements in the target model and a selection of the elements for which a mapping has not been found in the opposite model is transformed into elements of the target model. Each merge rule defines the types of elements it can merge, as well as a list of elements it produces in the target model. It also defines exactly how the source elements are linked to the newly created elements in the target model. Similarly, each transformation rule defines the instances it can transform, and a list of the model elements it produces in the model.

5 EXPERIMENT

Let us consider SoftChallenge, a software company producing logistic systems. At 2017 it has chosen to be certified ISO 9001, in order to improve its business processes. Therefore the quality team needs a check list of the ISO 9001 requirements. The quality engineer has integrated ISO 9001 requirements in SoftChallenge UQ repository. At 2020, SoftChallenge decided to improve its software engineering activities by the CMMI standard certification. SO CMMI requirements must be integrated in SoftChallenge UQ repository.

We assume that the ISO 9001 standard is the first quality standard deployed in the company, and that our main objective is the deployment of the CMMI standard while pursuing our UQ approach. In our case, we will follow a single iteration of CMMI integration.

We are currently implementing a framework that helps the quality engineer in training the new standards in the UQ repository. In this article we will use the framework in the application of the first part of the process, the second and third part will be applied manually, and the final version of the framework will be described in details in a future work.

In view of the volume of ISO 9001 and CMMI standards, we chose just the two-part of both standards. We have chosen the two most convergent parts in order to visualize the approach and its benefits.

We have chosen Article 4 Quality management system of the ISO 9001 standard[REF]. And the generic goals of the CMMI standard[REF]. !

5.1 Step 1. Loading the CMMI Original Model

In this task, we use the UQ framework in order to instantiate the CMMI standard, the figure 4 presents the generic goals and practices of the CMMI standard.

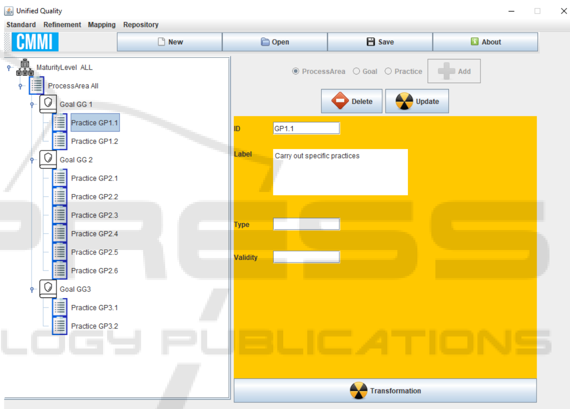

Figure 4: Generic goals and practices of the CMMI standard.

The transformation rules is illustrated in the table1 The result of the transformation gives us the pivot model enriched by the instances of the CMMI standard.

5.2 Step 2: CMMI Refinement in UQ Pivot Model

We elaborate the refinement of the requirements of the CMMI UQ Pivot model by illustrating an example of a requirement, we have chosen the GP2.5 requirement, which is: GP2.5 *Identify and involve the parties concerned*. As shown in Figure 6, this requirement has two features, the identification of the parties concerned and their involving.

$$F(GP2.5) = (GP2.51, GP2.52) \quad (3)$$

Table 1: The transformation rules from CMMI to the UQ Pivot.

Source	target	Attribute
	Standard	- id-s: CMMI - label-s: Capability Maturity Model Integration - validity-s:
Maturity Level	Compound rubric	- id-r: id-m - label-r: label-m - type-r: maturity level
Process Area	Compound rubric	- id-r: id-pa - label-r : label-pa - type-r: process area
Goal	Elementary rubric	- id-r: id-g - label-r: label-g - type-r: type-g
Practice	Requirement	- id-rp: id-p - label-rp: label-p - type-rp: type-p - validity-rp : validity-p

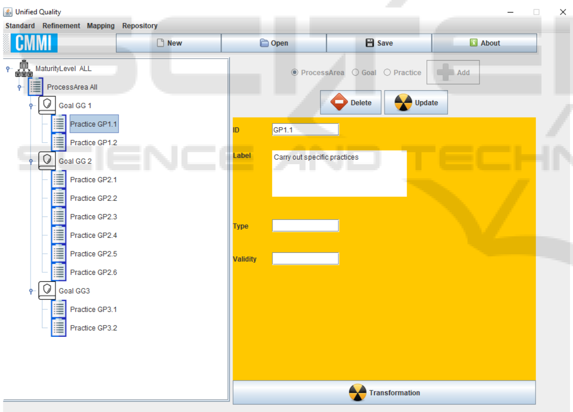

Figure 5: Result of the transformation from CMMI model to PIVOT model.

5.3 Step 3: Updating UQ Repository

The experimentation of this part is done in two parts:

5.3.1 Task 1. Requirement Mapping

In this part we will elaborate the mapping between the requirements of the UQ repository and those of the UQ pivot Model. As explained in the requirements mapping paragraph, this task is done in two steps, rubric mapping and requirements mapping.

As a reminder, the example chosen ISO 9001

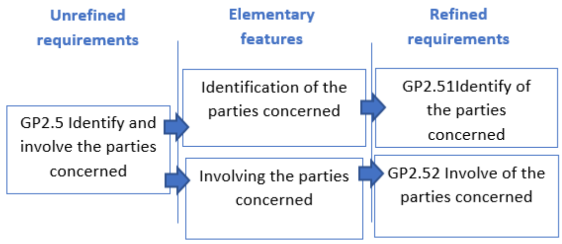

Figure 6: Example of a refinement of a requirement.

rubrics are

- 4.4 Quality management system and its processes.

And the example chosen CMMI rubrics are:

- GG1 Achieving specific objectives
- GG2 Institutionalize a managed process Plan the process
- GG3 Institutionalize a defined process Establish a defined process

The result of the RQM function between the rubric 4.4 and the GG1 rubric is RQM(4.4, GG1)) = 0, but for the example of the two rubrics 4.4 and GG2 the RQM (4.4, GG2) equals to 1.

We conclude from the rubric mapping result that, it is not necessary to process the mapping between the requirements of rubric 4.4 and GG1 because there is no reconciliation between the two rubrics, and in this case the QM mapping function between these requirements equals to 0. for each requirement of 4.4 and r requirement of GG1 MQ(r,x) = 0. Which gives us the benefit of analyzing the requirements of these two rubrics.

On the other hand it is necessary to analyze the mapping between the requirements of the rubric combinations (4.4 GG2) and (4.4, GG3). To illustrate, using the example of (4.4 GG.2); The result of the requirements mapping of the rubric 4.4 and GG2 is shown in table2. The case of requirement GP2.1 (*Provide resources*) and the requirement d1(*determine the resources needed for these processes*), these two requirements cover the same functionality, which is the determination of the resources for the processes. Then there is a mapping between the two requirements and the function RQM(d1, GP2.1) = 1. On the other hand, the example of requirement pair GP2.3 (Educating people) and g1 (Evaluate these processes), illustrates the case of absence of mapping and the function RQM(g1,GP2.3) = 0.

Table 2: Result of the mapping of the requirements of rubric 4.4 and GG2.

RQM	a	b	c	d1	d2	e	f	g1	g2	h
GP2.1	0	0	0	1	0	0	0	0	0	0
GP2.2	0	0	0	0	0	1	0	0	0	0
GP2.31	0	0	0	0	0	0	0	0	0	0
GP2.32	0	0	0	0	0	0	0	0	0	0
GP2.4	0	0	0	0	0	0	0	0	0	0
GP2.5	0	0	0	0	0	0	0	0	0	0
GP2.6	0	0	0	0	0	0	0	1	0	0
GP2.7	0	0	0	0	0	0	0	0	0	0

5.3.2 Task 2. Integration of the UQ Pivot Model to the UQ Repository

We proceed in this task to integrate the pivot UQ model in the UQ repository.

The pivot model requirements that have a mapping of the requirements from the UQ repository will not be integrated into the UQ repository but all the others will be integrated, in the table3 shows the result of the example integration of the GG.2 field.

Table 3: The UQ repository containing article 4 of the ISO 9001 standard.

Rubric	RequirementP
Quality management system and its processes	a) determine the inputs required and the outputs expected from these processes; b) determine the sequence and interaction of these processes; c1) Determine the criteria and methods ... c2) Apply the criteria and methods. d1) determine the resources needed for these processes d2) ensure their availability; e) assign the responsibilities and authorities for these processes; f) address the risks and opportunities ... g1) valuate these processes g2) implement any changes needed... h) improve the processes and the QMS.
GG 2 Institutionalize a managed process Plan the process	GP2.3) Educating people GP2.4) Work control products GP2.51) Identify the parties concerned GP2.52) involve the parties concerned GP2.7)Review Status with Higher Level Management

6 CONCLUSION

Even if, software quality assurance approaches have reached a maturity and their standards are popular, their deployment is mastered when only one of them is deployed. But in the case of the co-deployment of several quality standards, many problems remain and are the subject of extensive research. The originality of UQ approach is first to provide an gradual and agile integration of standards according to the company needs and vision. Secondly the approach is based on formalisation and MDE. The quality engineer have a unique quality check list to drive his audit, avoiding redundancy and ambiguity.

The approach consists of two processes, configuration and audit. The approach's configuration process aims to integrate several standards into the same optimal UQ repository. The standards are integrated in an incremental way capitalizes on the building of the UQ repository and its training, It is divided into two sub-processes for this purpose. The first one is the building of the pivot meta-model that presents the structure of the UQ repository and second one is the training process of this repository which is the subject of this paper. This repository allows to unify the different structures of the quality standards in order to solve their heterogeneity and redundancy issue. The second process of Unified Quality approach is devoted to the quality audit of a specific organization. . The audit process will be addressed in subsequent work. The models of the UQ approach are reusable and independent of the company. We are in the process of implementing a final application that facilitates the application of the UQ approach as well as we are still working on the audit process that will be the subject of the next article(Kitchenham, 2013).

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