An Ontology for Quality Standards Integration in Software Collaborative Projects

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Abstract. The objective is to integrate several process using a common ontology offering various viewpoints. This methodology is applied to the integration of two quality standards - ISO 9001:2000 and CMMI - in order to generate a multivues quality ontology allowing a double certification relative to these two standards. This work is carried out within a software engineering company (Sylis). Human and cultural aspects of the company are considered in order to make acceptability easier. Finally, the question of processes interoperability is discussed.

Key words: Ontology, Quality standard, Interoperability, Quality reference frame, ISO 9001:2000, Capability Maturity Model Integration

1 Introduction

Quality standard ISO 9001:2000 gives organizational requirements for a quality management system implementation; it is generic and can be applied in any organization. CMMI (Capability Maturity Model Integration) is an interdisciplinary systems engineering covering technical and managerial processes and abilities for software and computing services; it is focused on software development and maintenance. Within the framework of collaborative software projects, the questions are: How to apply these two (or more) quality standards without to describe the processes twice? How to give the proof to the auditors of each quality standard respect? We present the implementation of these quality standards in a unique ontology allowing to answer these two questions, in order to make the collaboration with other companies easier.
The paper is organized as follows: section 2 gives a brief explanation of ISO 9001:2000 and CMMI. Section 3 introduces our proposal of integrated model. Section 4 presents the implementation of this model. Section 5 gives some practical solutions for processes interoperability between the company and its offshore suppliers or clients, and finally, section 6 provides our conclusions.

2 Presentation of the quality standards

2.1 ISO 9001:2000

ISO 9001:2000 is a necessary requirement for a quality management system. It is a part of the ISO 9000 family that consists of ISO 9000 (Fundamentals and Vocabulary) [11] [13], ISO 9001 (Requirements) [10], ISO 9004 (Guidelines for Performance Improvements) [12], and ISO 19011 (Guidelines for Quality and Environmental Management Systems Auditing). ISO 9001:2000 is an abstract and is a sparse document that can be applied to any category of business.
When it is to be applied to organizations in the software industry, ISO 9001 can be further interpreted by using either ISO 9000-3 or TickIT.

ISO 9001:2000 is based on eight quality management principles:

1. Customer-focused organizations: an organization must understand its customers and their needs;
2. Leadership: leadership is reflected in organizational direction, motivation, and communication of goals and objectives through all organizational levels;
3. Involvement of people: people must be recognized for their contributions and must be involved in decision making;
4. Process approach: any activity or set of activities that transforms inputs to outputs can be considered a process. In any organization, many processes interact in various ways during the product life cycle;
5. System approach to management: a system is a set of interrelated or interacting elements or processes. Therefore, an organization can be considered to be a system of interrelated and interacting processes;
6. Continual improvement: this principle requires an organization to set continual improvement as one of its permanent objectives;
7. Factual approach to decision making: to be able to base decisions on facts, processes have to be measured and those measurements must then be used for quantitative decision making;
8. Mutually beneficial supplier relationships: no organization operates alone. The supply chain must be taken into account when developing a product.

The result of ISO 9001 positive audit is a certificate, proving that the organization comply with the standard requirements. This certificate has a limited duration.

2.2 Capability Maturity Model Integration

Currently, there are several maturity models, standards, methodologies, and guidelines that can help an organization improve the way it does business. However, most available improvement approaches focus on a specific part of the business and do not take a systemic approach to the problems that most organizations are facing. For example, maturity models such as the Software Engineering Institute's (SEI's) Capability Maturity Model for Software (SW-CMM),

which focuses on improving software, and the Electronic Industries Alliance's (EIA's) Systems Engineering Capability Model (SECM), which focuses on systems engineering are available. By focusing on improving only one area of a business, these models have unfortunately perpetuated the barriers that exist in organizations.

Capability Maturity Model Integration (CMMI) provides an opportunity to avoid or eliminate these barriers through integrated models that transcend disciplines. CMMI consists of best practices in software companies. It addresses practices that cover the product's life cycle from conception through delivery and maintenance. There is an emphasis on both systems engineering and software engineering and the integration necessary to build and maintain the total product [7].

CMMI integrates old models developed in the Nineties. This need for integration appeared in order to make speak the same language and use common processes engineers of multiple disciplines attached to the same project of development: SE (Systems Engineering), SW (SoftWare), SS (Supplier Sourcing) and IPPD (Integrated Product and Process Development).

CMMI regroups 25 "Process Area" (PA: a cluster of related practices in an area). There are two different representations of the CMMI: the staged representation and the continuous representation [1], [15]. The result of a CMMI evaluation is a list of strenghts and weaknesses designed to begin a continuous improvement approach. The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) is designed to provide benchmark quality ratings relative to Capability Maturity Model Integration (CMMI) models. So, a team of evaluators can give a maturity level to the evaluated organization by applying SCAMPI.

CMMI Staged Representation CMMI pushes to increase the maturity of the processes. The Staged Representation focuses improvement on the process capability an organization can expect to attain; however, this expected capability (or ability to function in a mature manner) is contained within maturity levels or stages. There are five maturity levels, as shown in figure 1, with each level providing the foundation for further improvements. This representation provides a roadmap for sequencing the implementation of groups of process areas.

CMMI Continuous Representation The Continuous Representation has the same basic information as the staged representation, just arranged differently. The continuous representation, as shown in figure 2, focuses process improvement on actions to be completed within process areas, yet the processes and their actions can span different levels. More sophistication in implementing the practices is expected at the different levels. These levels are called Capability Levels. There are six Capability Levels that focus on maturing the organization's ability to perform, control, and improve its performance in a process area. This ability allows the organization to focus on specific areas to improve the performance of that area. The continuous representation provides maximum flexibility

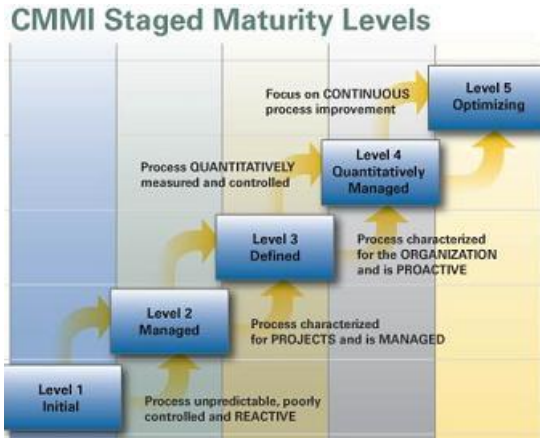

Fig. 1. CMMI Staged Representation

for focusing on specific process areas according to business goals and objectives [14].

Fig. 2. CMMI Continuous Representation

In our case, we focused on Staged Representation in order to improve all the PAs and not to restrict our work to particular ones.

3 Proposal of an integration model

3.1 Model description

Each quality model, standard and corpus of knowledge describes a part of company activities with its own level of precision and specificity [3]. Their scope is different (as shown in figure 3), and the two models have common and specific descriptions. Moreover, one model can describe non existing activities in the company and forget some other existing and implemented activities; usually a model does not cover integrally enterprise activities. In addition, the precision level of the description depends on the model.

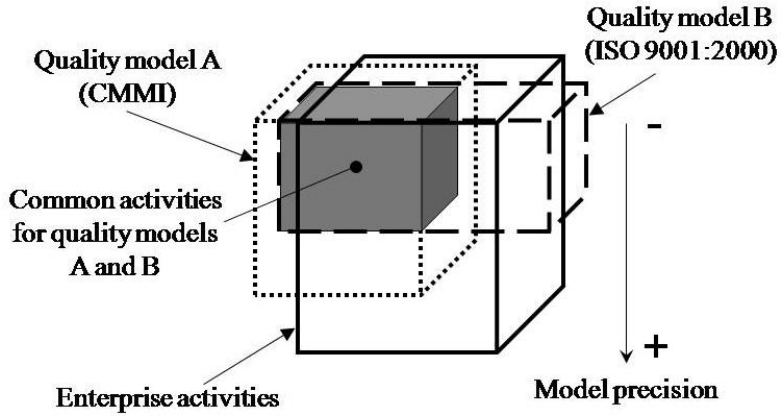

Fig. 3. Models scope compared to enterprise activities

3.2 The multi-model approach

We propose four steps in our multi-model approach to integrate different quality models:

Step 1 : Models choice In a first time, the enterprise has to answer some questions:

- What are objectives and requirements? (Increase customer satisfaction, productivity...);
- What are envisaged models? (CMMI, ISO 9001:2000, ItIl...);
- Which the budget? (Training, software acquisition...);
- What are resources? (Young people, experimented, consultants, significant number...).

Then, we can determine coherence between considered models and enterprise needs and resources. This step permits us to choose the adequate models to implement.

Step 2 : Analysis of models synergy Once the models are chosen, we compare those standards. This comparison points to both similarities and differences. Fortunately, the synergy between the frameworks can be exploited and the weaknesses of one can be supplemented by the strengths of the others. To analyze models synergy, we implement a mapping between models. This mapping should determine:

- Levels of abstraction between selected models;
- Treated functional sectors;
- For each element of a model, its relation with elements of other models;
- A level of correlation, in order to qualify each relation.

Step 3 : Construction of integrated model As shown in figure 4, this step will allow us to:

- Resolve all contradictions in the relations between the elements of models;
- Avoid unfolding of work by consolidating the elements with relations of inclusion and identity;
- Maximize the synergy potential by combining complementary elements.

Then, we create a theoretical integrated model valid for any enterprise wanting to implement two models A and B.

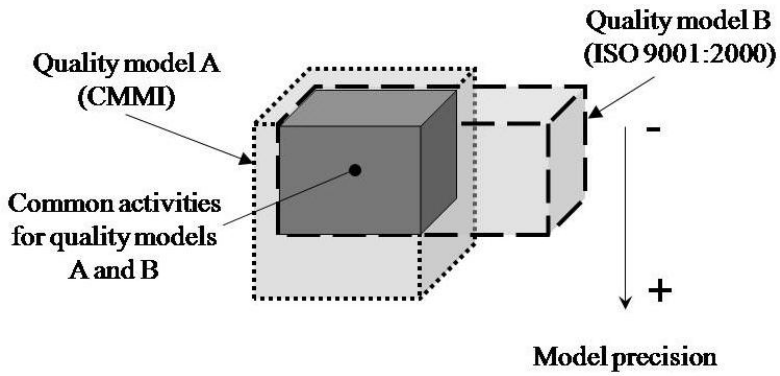

Fig. 4. The integrated model

Step 4 : The adaptation of the integrated model to the enterprise context This step allows us to retain from each model only relevant elements with enterprise activities (as shown in figure 5) and objectives of quality project and to adapt the theoretical integrated model to human and cultural context of the enterprise.

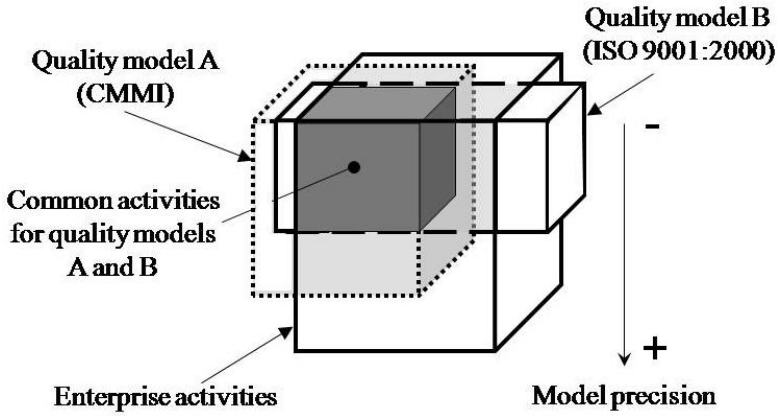

Fig. 5. The specific integrated model

4 Implementation of the ontology

The previous method has been implemented in the case of Sylis company. The models to be integrated were CMMI and ISO 9001:2000.

4.1 CMMI and ISO 9001:2000 mapping based on the ontology

The figure 6 shows our proposal of an ontology. Each quality standard is composed of one or several set of recommandations wich regroups a set of practices. The terminology is different from a quality standard to another. For CMMI, we have Process Area (PA) then practices (GP for Generic Practices and SP for Specific Practices). For ISO 9001:2000, we have chapters then subchapters. Some quality standards define levels of maturity which is a regroupement of recommandations already defined by the standard. We can define an association class "Mapping" to define synergy between practices with a level of correlation (strong, medium or weak).

The figure 7 presents an object diagram modeling a part of ISO 9001:2000 and CMMI mapping. This diagram shows a relation with a correlation level "strong" between:

- PMC-SP2.1 "Collect and analyze the issues and determine the corrective actions necessary to address the issues" part of the CMMI's Process Area "Project Monitoring and control" which is including in the Maturity Level 2.
- Subchapter "8.5.2-Corrective Action" part of the section 8: "Measurement, analysis and improvement" which is an ISO 9001:2000 chapter.

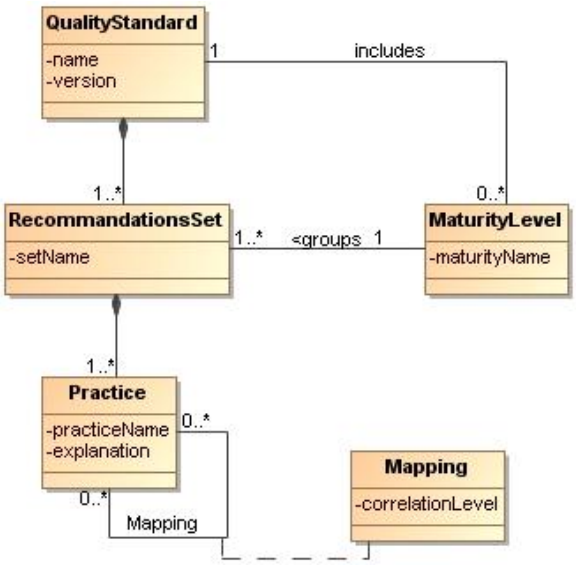

Fig. 6. The class diagram of quality standards

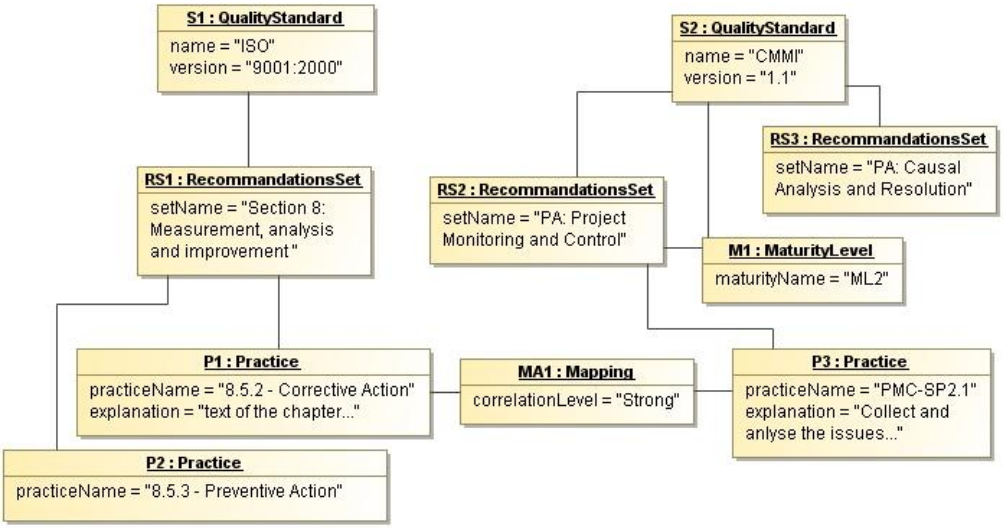

Fig. 7. The object diagram of implemented quality standards (ISO 9001:2000 and CMMI)

Basing on CMMI and ISO 9001:2000 synergy [5] [6], we implement a mapping in order to determine:

- CMMI practices treated par ISO 9001:2000 chapters;
- ISO 9001:2000 chapters treated par CMMI practices.

4.2 Implementing enterprise quality ontology

Implementing the specific integrated model As shown in figure 8, basin on the mapping we implement a cartography of enterprise processes. This cartography shows the enterprise processes and CMMI PAs. It shows also the level of integration of CMMI Processes Area (PA) in our cartography. PAs: Decision Analysis and Resolution (DAR), Integrated Teaming (IT), Organizational Environment for Integration (OEI), Integrated Supplier Management (ISM) and Risk Management (RSKM) are not treated by ISO 9001:2000. All the rest of CMMI Processes Area are localized in our ISO procedures.

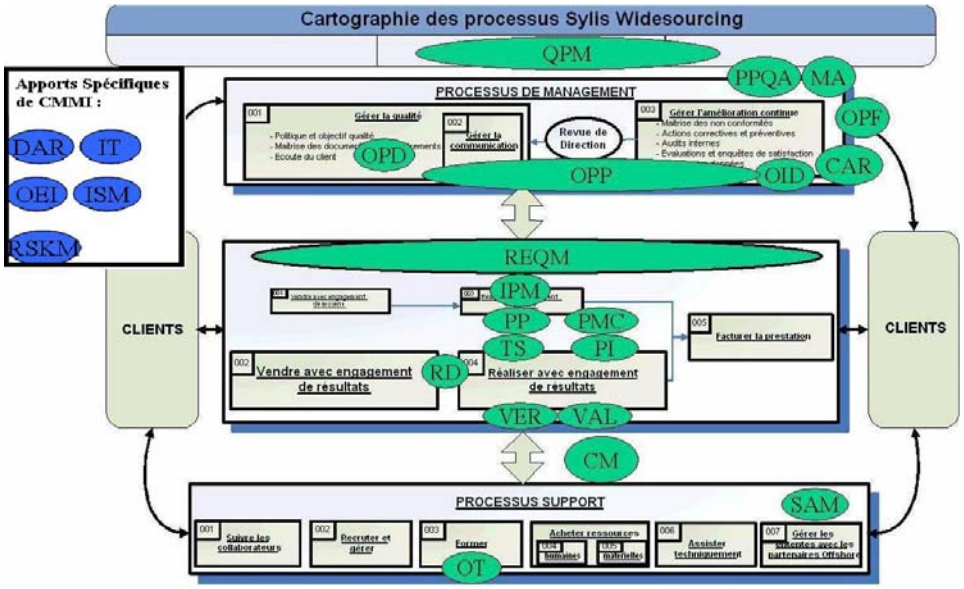

Fig. 8. Entreprise's process cartography including CMMI Processes Area basing on ISO 9001:2000 representation

Enterprise processes and quality standards mapping As shown in figure 9, we implement a mapping between enterprise processes and our quality standards implemented. So for an enterprise process, we can find all CMMI Processes Area and ISO procedures treated by this process and vice versa.

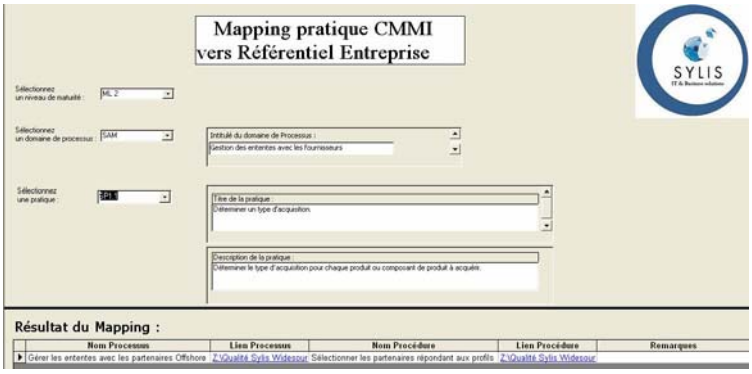

Fig. 9. CMMI - enterprise reference frame mapping

4.3 Example of implemented process

As shown in figure 10, we attached for each implemented process:

- The definition of all procedures and instructions called for the execution of the process;
- The entries and the results of each procedure;
- All concerned actors of the execution of each procedure.

We defined also for each implemented process:

- Process's risks;
- Process's performance indicators;
- CMMI's Process Areas (PA) implemented in the process.

4.4 The project reference frame

The purpose of the project reference frame is to create a repertory standard structure. This structure contains all templates usable along the project. This standard repertory will be duplicated for all projects. The objectives are:

- Create a unique repertory structure for all projects;
- Create templates usable in all projects;
- Standardize documents and methods used in all projects;
- Accelerate documents production;
- Share knowledge and references within Sylis France;
- Ensure the respect of quality reference frame.

The figure 11 shows a screen print of the project reference frame accesible for all collabotors.

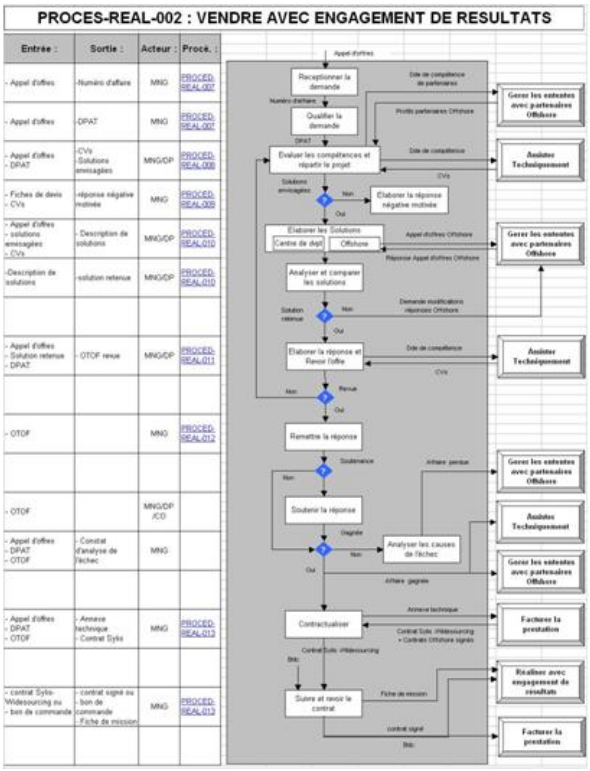

Fig. 10. Example of implemented process

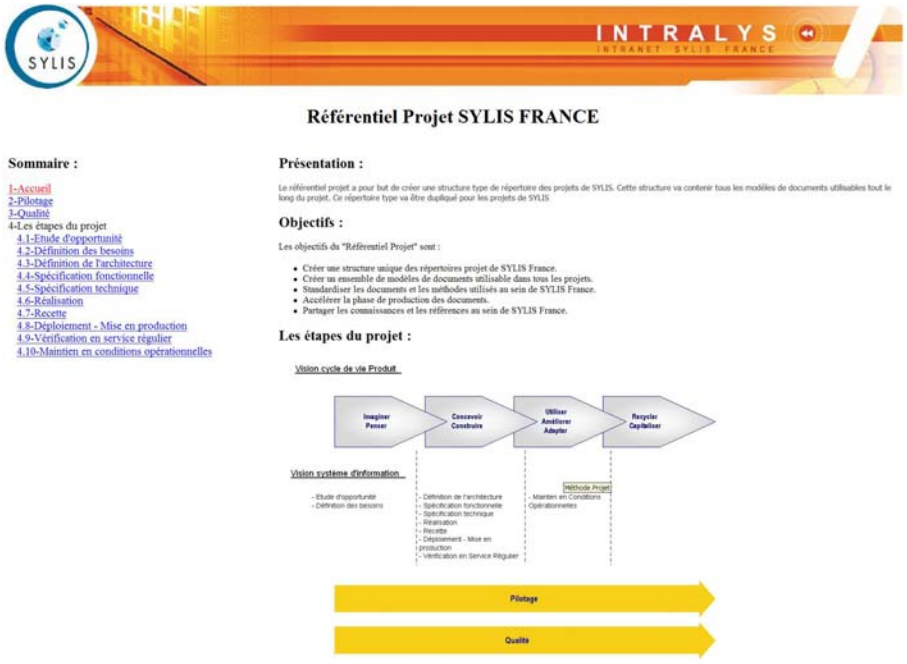

Fig. 11. A screen print of the project reference

4.5 The human aspects for acceptance

Since the company has its own methods and ways of work, we feared that the integrated model will not be used. So, we dealed with the problem of acceptance. Thus, we began by classifying the personnel of the company in two categories:

- *The allies:* they approve work and are convinced of its utility and the need on the implementation of such model in the company;
- *The recalcitrants:* they are a little bit hostile to the implementation of such a model because:
  - Usually, they do not use methods of estimation;
  - They have their own models.

We concentrated our efforts on this second part of the personnel. We choose the strategy of persuasion through presentation to show the advantages of the adopted model compared to classic quality standards and by discussing with them to know which are their waitings and if there are things to modify.

5 Processes interoperability

Currently, the processes for software development in Sylis have been described and are accessible via the intranet of the company by all the project managers. These processes have to be linked with those of external organization. Indeed, Sylis does not generally manage the totality of a software project. Often, the requirements analysis is given by the client: a document is given at the time of the call for bids that constitutes the beginning for the detailled specifications. In other cases, a part of the software development is entrusted to an offshore supplier. So, in these two cases, a part of the internal processes are shunted.
For the case of suppliers, in compliance with ISO 9001:2000 recommendations and specially CMMI, Sylis has to select its potential contractors and to control the quality of their deliverables. That can be done by the selection of contractors that are certificated (ISO 9001:2000) and/or the obligation for them to have a given level of maturity (CMMI). But more concretely, it is necessary to define precisely the informations that must be exchanged between the two partners. It is a problem of processes interoperability. A solution should consist in the building of new processes models that take both the works and the responsabilities repartitions between actors into account, but it is very difficult to do. Indeed, the description formalism to express the processes is never the same for the different companies (even if some de facto standards like UML or BPMN are emerging), and moreover these models often are confidential. It is so necessary to do a manual mapping between the two organizations descriptions and to consider exchanges as inputs / outputs between black boxes. In order to facilitate this work, an intermediary process, based on CMMI, has been defined.
For the relations with the client, the difficulty is about the same, but moreover, as supplier, Sylis cannot require a quality level from its clients. Two actions are performed. First, to define the prerequistes for software development in good

conditions; this makes it possible to do a risk analysis: an evaluation of the client is made in prepurchase that is taken into account for the selling price determination (the risk is payed by the client). Secondly, a support can be given to the client to improve his software development methodology; so, the client makes progress and Sylis is seen not only as software and computing services company, but also as partner for its progress.

6 Conclusion

In our paper, we have presented an ontology for quality standards in the context of software collaborative projects. We have implemented a unique quality reference frame integrating CMMI and ISO 9001:2000. We have implemented also some practical solutions for processes interoperability between the company and its offshore suppliers or clients to organize projects and especially documents exchange.
To implement CMMI in an ISO 9001:2000-certified organization efficiently and effectively, both the common and different parts of the ISO 9001:2000 standards and CMMI documents must be identified. ISO 9001:2000 requirements can be mapped to CMMI practices [6]. However, the following limits have been identified in this mapping process:

1. A requirement of ISO 9001:2000 can be mapped to many CMMI practices. Conversely, a CMMI practice can be mapped to many ISO 9001:2000 requirements. These mappings are useful for comparing these two frameworks, but they may cause confusion during the decision-making process.
2. It is difficult for organizations to understand and apply these mappings during CMMI implementation because they only describe the degree of the correlation between ISO 9001:2000 and CMMI without providing any explanation of these mappings.
3. The structure and words that are used by CMMI are not familiar to ISO-certified organizations, which makes it more complicated for an ISO 9001:2000-certified organization to implement CMMI.

We are working now on mitigating these limits and the implementation of more than two quality standards on the same ontology. Another prospect is to develop automatic mapping tools between models, rather than to make this mapping manually.

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