DEVELOPING A KNOWLEDGE PROCESS QUALITY MODEL EVALUATION SYSTEM USING COMMONKADS

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Abstract: Several knowledge management maturity models have been proposed in the last years. These models are used to evaluate the quality of knowledge management practices in the organizations. One of these models is the Knowledge Process Quality Model, which has five maturity levels. The acquisition of a high maturity level is usually expensive due to the evaluations and improvement processes that are often required for a positive final decision. With the aim of minimizing these costs, this paper proposes a Knowledge-Based System that tries to check if the company currently stands in compliance with a given KPQM maturity level. The actual evaluation process starts only if the system output is positive. This approach implies an important cost reduction by avoiding negative evaluations. The design of the system is based on the CommonKADS methodology, and its implementation was carried out with the Clips tool.

1 INTRODUCTION

According to Kuriakose et al. (2011), Knowledge Management (KM) is a discipline that tries to create wealth and value by providing the right knowledge at the right place and at the right time. The effective use of knowledge by several organizational entities results in improved skills and competencies for decision making, performance improvement and also innovation. Thus, the organizations had devoted numerous efforts for retaining and institutionalizing the knowledge they possess (Davenport and Prusak, 2000). In this way, there are several KM initiatives in the literature (Ares et al., 2008) that try to establish guides for effectively implementing and developing the KM in the organizations.

The following obvious step involves the set up of mechanisms for assessing how well these KM initiatives are deployed in the organizations. This assessment focuses on the quality of the organization processes, as well as in the mechanisms used for achieving and keeping these processes. The later mechanisms should also be used as a guide for continuous improvement.

As a result, there is a growing number of the so-called Knowledge Management Maturity Models (KMMM). Examples of these initiatives are: the KMf and KM^3 models (Gallagher and Hazlett, 2000), the KPMG Knowledge Journey (KPMG, 2000), the model proposed by Gabor Klimko (2001), the Knowledge Management Capability Assessment (KMCA) (Kulkarni and Freeze, 2004; 2005), the Knowledge Process Quality Model (KPQM) (Paulzen and Perc, 2002) and the model proposed by Infosys (Kochikar, 2000).

The compliance with a high KM maturity level increases the prestige and competitiveness of the organizations. However, the evaluation process is often quite expensive. An auditor has to determine the compliance with a given KM maturity level. In the case of non compliance, the defects detected have to be solved and a new audit is required to the evaluation of the organization in the desired KM maturity level.

This paper proposes a Knowledge-Based System (KBS) for the evaluation of an organisation in a KM maturity level. This KBS will return a positive or negative compliance report with regards to the given KM maturity level. The services of the auditor are required only when the result of the KBS is positive.

There is a high matching probability between this report and that of the auditor, but sometimes this matching may not happen, since the auditor may consider certain aspects that are not considered by the KBS. These aspects are also useful, since the inclusion of new knowledge will improve the KBS.

The KPQM model, proposed by Paulzen and Perc (2002), was selected because its structure and

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processes are well detailed. This model is based on the ideas of two software development maturity models: the Capability Maturity Model (CMM) (McCollum, 2006) (Persse, 2001) (SEI, 2011) and the Software Process Improvement and Capability dEtermination (SPICE) (SPICE, 2011).

The KPQM model description and the design of the proposed KBS are detailed in Section 2; Section 3 shortly describes the KBS implementation, and Section 4 sets out the conclusions.

2 DESIGN OF THE PROPOSED SYSTEM

2.1 KPQM Description

Starting from the CMM and SPICE models, Paulzen and Perc (2002) developed a model that allows the assessment of KM processes in an organization. The model also provides a summary of the steps to be followed in order to reach some improvements. The model includes five maturity levels (see Table 1).

Table 1: Maturity levels.

Maturity Level	Description
1. Initial	The quality of the knowledge processes is not defined and it randomly changes. This level could be described as chaotic.
2. Aware	The need of managing knowledge processes starts to be borne in mind. The first structures for guarantying a better quality of processes are implemented.
3. Established	A systematic structure and a definition for knowledge processes are established.
4. Quantitatively Manager	The systematic management of processes is emphasized by means of performing output measurements for their planning and guidance.
5. Optimizing	There are structures for continuous improvement.

Each maturity level defines a series of issues with which the organization must comply. That structure, as Table 2 shows, rests on the following dimensions: Organization, People and Technology.

The KBS design has to reflect that structure in order to assess the compliance with all the maturity levels defined in the KPQM.

Table 2: Assessment structure.

Level	Dimension	Issue
1	Organization	-
	People	-
	Technology	-
2	Organization	Defined and documented processes. Process-native basic abilities and structures.
	People	Structures for the employees to consider KM processes. Structures for the direction to consider KM processes.
	Technology	It includes part of the technological support for KM methods.
3	Organization	Process standardization. Structured knowledge.
	People	There is an incentive system for employees in order to boost the use of knowledge. There is an incentive system for executives in order to boost the use of knowledge.
	Technology	There is a systematic technological support for the processes.
4	Organization	The processes are quantitatively assessed. The management decisions are quantitatively assessed.
	People	The incentive system for employees is quantitatively assessed. The incentive system for executives is quantitatively assessed.
	Technology	The impact of the technological support is quantitatively assessed.
5	Organization	There are structures for improving the processes. There are structures for improving the management.
	People	There are structures that promote the continuous improvement in the use of knowledge. There are structures that guarantee that the management might keep involved in the KM tasks.
	Technology	The process-supporting technologies are optimized. Pilot projects are carried out.

The quality of the KBS design depends on the programming skills of the knowledge engineers and also on their abilities to devise, remember, and dynamically update a design specification. This is a difficult task for all but the smallest KBSs.

Difficulties like these can be alleviated by producing textual representations or diagrams of expert knowledge and design specifications. The best known approach for producing such documents is the CommonKADS methodology (CommonKADS, 2011) (Schreiber, 2000) (Kingston, 1998) (Valente, 1998). CommonKADS is the current European *de facto* standard for knowledge analysis and knowledge-intensive systems development. This methodology has been wholly or partially incorporated to existing methods by many major companies in Europe, US and Japan (CommonKADS, 2011). CommonKADS was used in this work for elaborating a list of potential model components for the KBS, selecting the adequate task template, constructing the initial domain scheme, and completing the specification of the knowledge model. The following sections describe how these activities were carried out.

2.2 List of Potential Model Components

The task of the proposed KBS belongs to a highly specialized field (a concrete and classified theme within Quality Management). Mainly due to this reason there is information available on how to carry out audits (SEI, 2011). Consequently, the knowledge of the domain can be considered as formal.

On the one hand, there is evidence of the existence of a commonly accepted structure in the KPQM model—shown in Figure 1—that represents an initial candidate for the domain model. This structure reflects the existence of five maturity levels and three common dimensions. Each dimension is related to a set of issues in each maturity level.

Also, a maturity level requires a certain level of compliance with each dimension, and each dimension contains a series of issues presented by maturity-shaped questions. We have been able to define these questions thanks to the KPQM literature and the information available on how to carry out audits (c.f., e.g., SEI, 2011).

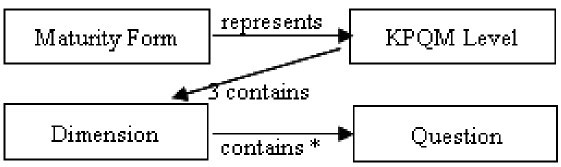

Figure 1: Initial relationships structure.

On the other hand, it is essential to record the performed audits and their results (e.g. in a file or database). Therefore, before resolving the question about a KM maturity level *n*, the KBS has to check if the organization satisfies the KM maturity level *n-1*. This practice follows the Quality Management philosophy, which stands on not skipping maturity levels. In that way, level 2 should be previously achieved in order to reach level 3.

2.3 Selection of the Task Template

The aim of the proposed KBS is to fill a form with organizational information and analyze it in order to determine if the organization currently stands in compliance with the selected KPQM maturity level; that is, if an actual evaluation is possible.

In this context, and from the point of view of the task, this is an activity that fits into the category of assessment. These activities are provided with various templates, from which we have selected the one mentioned in Schreiber et al. (2000).

The main motive for this choice is that the associated inferential structure matches the purpose of the KBS. A good technique to establish this adequacy is building an annotated inferential structure in which the roles are annotated with specific elements of the domain. This inferential structure is shown in Figure 2.

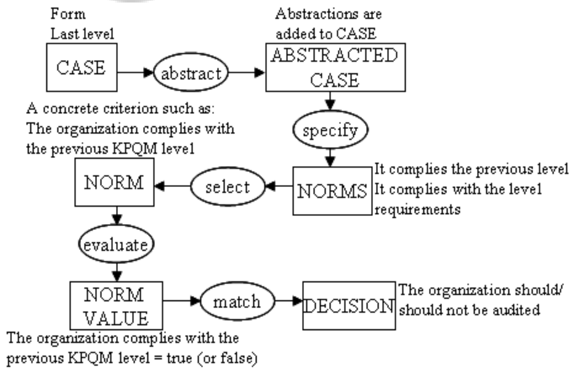

Figure 2: Annotated inferential structure.

2.4 Construction of the Initial Domain Scheme

The result of this task is a set of domain-specific conceptualizations — shown in Figure 3 — and a set of method-specific conceptualizations — shown in Figure 4.

Two main concepts were detected in the domain: *Form* and *Section*. The information about the last KPQM level reached by the organization was also required and it is represented by the concept *Record*.

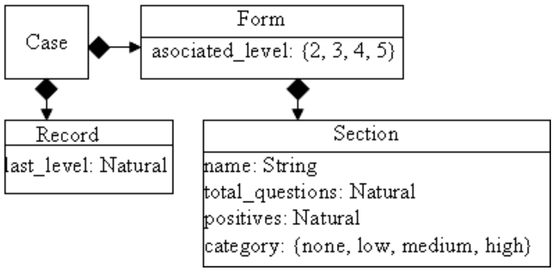

Figure 3: Domain-specific conceptualizations.

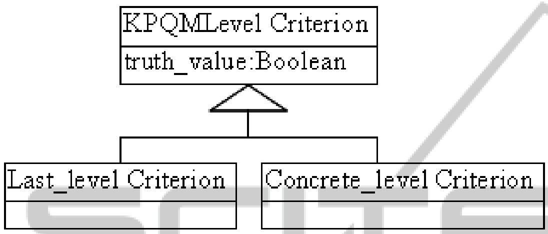

Figure 4: Method-specific conceptualizations.

The *Form* and *Record* concepts constitute the initial reasoning case. A *Form* refers to a specific KPQM level and consists of three sections each of them representing a dimension (Organization, People, and Technology). There is an aggregation relationship between the concepts *Form* and *Section*. The concept *Form* has an attribute *associated-level* that indicates the desired KPQM level. The concept *Section* has four attributes: *name*, *total-questions, positives*, and *category*. The first refers to the name of the dimension—e.g. People—, the second indicates the total number of issue-related questions in the dimension, the third represents the total number of positively answered questions, and the last attribute refers to the level of compliance with the section. This level of compliance is obtained by means of the *total-questions* and *positives* attributes as follows:

- If the positive answers represent less than 25% of the total, the level of compliance is *none:* the organization does not comply with the dimension represented by the section.
- If the positive answers represent between 25-50% of the total, the level of compliance is *low.*
- If the positive answers represent between 50-75% of the total, the level of compliance is *medium*.
- If the positive answers represent between 75-100% of the total, the level of compliance is *high*.

Once it is determined how the domain concepts will be used, there should be settled the criteria to be applied to the data in order to determine the compliance with a given KPQM level. In this case, two different criteria are considered, each with a attribute *truth-value* representing whether or not the criterion is fulfilled:

- Last-level: Was the organization successfully audited in the level *n*-1?
- Concrete-level: Does the organization meet the requirements of the level *n*? The organization must meet the issues in the level dimensions at certain rates or levels (many possibilities are accepted).

Finally, it should be highlighted that the system only offers a positive answer if all the criteria have the *true* value.

2.5 Complete Specification of the Knowledge Model

As explained before, the activity to be modelled is an example of the task type assessment. Also, the selected template shows an adequate inferential structure for the purpose of this KBS, in which the inferences present sufficient detail.

The task that must be carried out is decomposed into two subtasks, which means that the *task method* structures the reasoning process in two steps:

- Abstraction: the purpose of this step is to achieve the compliance level for each section. As explained above, this level can be *none*, *low*, *medium* or *high*. For the KBS to reason as an expert does, the meaning of the number of the positive answers should be known. That is, the reasoning of an expert auditor may be: *The organization complies with all the dimensions at a medium level, but the People dimension must have a high level of compliance in this KPQM maturity level and I therefore consider that improvements must be made in that dimension*.
- Matching: the abstractions are matched in order to take the final decision on whether or not the organization complies with the established criteria.

Figure 5 shows the template that was chosen for the modelling.

On the other hand, the knowledge scheme that was finally obtained is shown in Figure 6. It can be observed that the final domain scheme incorporates three rule types:

- *Case-abstraction*: abstraction rules required for reaching the section compliance level by using the attributes *total-questions* and *positives*.

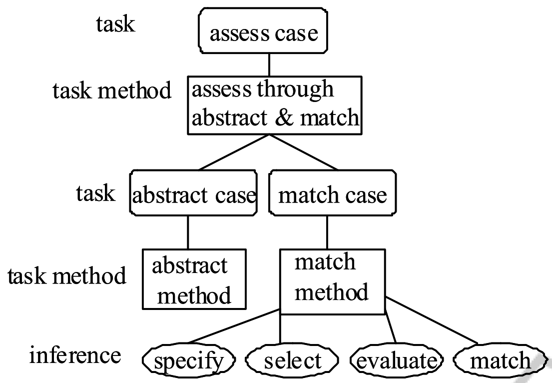

Figure 5: Decomposition of the task.

- *Form-requirement*: rules offering truth values to the criteria *Last-level* and *Concrete-level*. The first one indicates the compliance with the previous KPQM level and the second one indicates the acceptable compliance levels for the desired KPQM level.
- *Level-decision-rule*: The decision is represented by a concept *Level-decision* with an attribute that indicates whether or not the organization has real possibilities of successfully overcoming an audit for the desired KPQM level. Also, this rule expresses the relationship between the different criteria and the final decision taken by the KBS.

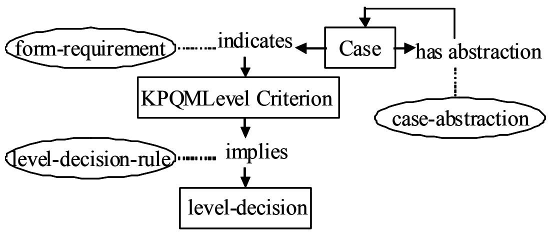

Figure 6: Final knowledge scheme.

3 IMPLEMENTATION OF THE PROPOSED SYSTEM

The system was implemented according to the CommonKADS design and by means of the *Clips* tool (Clips, 2011). In order to provide the application with modularity and to simplify the development and depuration processes, the following knowledge bases were defined:

- General: This knowledge base contains all the definitions of classes, objects, and properties. It contains the operative knowledge of the system. See for example, the concept Section definition:
  (defclass SECTION (is-a USER)
  (role concrete)
  (slot name (type STRING))
  (slot total-questions (type INTEGER))
  (slot positives (type INTEGER))
  (slot category (allowed-values none low medium high) (default none))
  and the object Org (KPQM dimension Organization) definition:
  (definstances SECTIONS
  (Org of SECTION (name Organization) (total-questions 25) (positives 15)
  … (rest of the instances))
- Abstract: This knowledge base contains the abstraction rules required for reaching the level of compliance with each dimension in the desired KPQM level. A rule example is as follows:
  (defrule is-organization-none
  (object (name [Org]) (test (< positives (* total-questions 0.25))) =>
  (send [Org] put-category none))
- Level2, Level3, Level4, and Level5: This knowledge base contains the rules for the evaluation of the criteria *Last-level* and *Concrete-level*. A rule example for Level 2 is as follows:
  (defrule level2-ok-1
  (object (name [Org]) (category high))
  (object (name [Peop]) (category medium))
  (object (name [Tech]) (category medium)) =>
  (send [ConLevel] put-truth_value true))
- Decision: These rules refer to the KBS final decision according to the values of the criteria specified above. A rule example is as follows:
  (defrule non-possible-1
  (object (name [ConLevel]) (truth_value false))
  (object (name [LasLevel]) (truth_value false))
  =>
  (send [LevDec] put-value false))

The Clips inference engine is started, the corresponding knowledge bases are loaded and the inferential process begins. Figure 7 shows an execution example in which an organization tries to be evaluated at level 4 after having been successfully audited at level 3. In this case the organization lacks an acceptable level of compliance with the defined dimensions.

4 CONCLUSIONS

In the current competitive context the effective KM

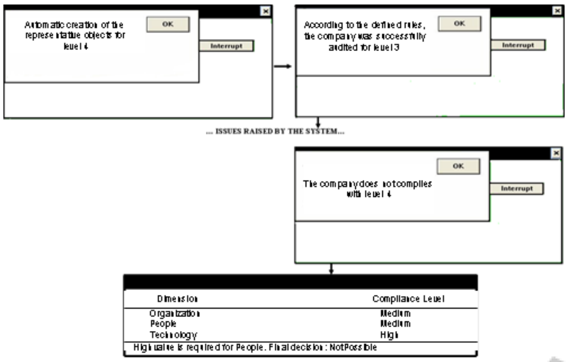

Figure 7: An execution example.

implies prestige and competitive advantages for the organizations. The evaluation of the quality of the KM initiatives is precisely the purpose of the KM maturity models. However, usually for reaching the desired KM maturity level an organization needs to overcome a series of expensive audits. This paper proposes a KBS to reduce these costs by limiting the audits to those cases in which the KBS output is positive; that is, the system considers that the organization complies with the desired KM level. The proposed KBS implements the evaluation following the KPQM model.

It should be highlighted that the developed KBS is currently being installed and tested in various companies at A Coruña, Spain, with which the authors have previously collaborated. Several test batteries have been run with virtual and real data in order to validate the system. At the moment, one of the organizations has been successfully evaluated in KPQM level 2 by the system and we are waiting for the auditor's decision in order to compare both results and improve the system if necessary.

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