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Aurélie Bissay, Philippe Pernelle, Arnaud Lefebvre, Abdelaziz Bouras

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KNOWLEDGE INTEGRATION THROUH A PLM APPROACH

Aurélie BISSAY, Lyon University, F- 69676, Bron, Lyon 2 Lumière University, LIESP
Phillipe PERNELLE, Lyon University, F- 69627, Villeurbanne, Lyon 1 University, LIESP
Arnaud LEFEBVRE, Lyon University, F- 69627, Villeurbanne, Lyon 1 University, LIESP
Abdelaziz BOURAS, Lyon University, F- 69676, Bron, Lyon 2 Lumière University, LIESP

ABSTRACT
This paper presents an approach of knowledge capitalization within a PLM (Product Lifecycle Management) system. We propose a methodology which allows knowledge integration through a PLM system. Knowledge integration is realized during the deployment of the PLM system and the processes definition stage. This paper is illustrated by an industrial example in the plastics industry.

1 INTRODUCTION

Companies have to conjugate customers satisfaction and the increase of their productivity. To respond to these constraints, companies need to be reactive and to reduce the development cycle of their products. Furthermore, the optimal re-use of the know-how is still not enough exploited within PLM systems. Any objective of cycle's reduction by the optimal re-use of the knowledge implies that the information system must be able to identify elements of knowledge but also be able to estimate them.

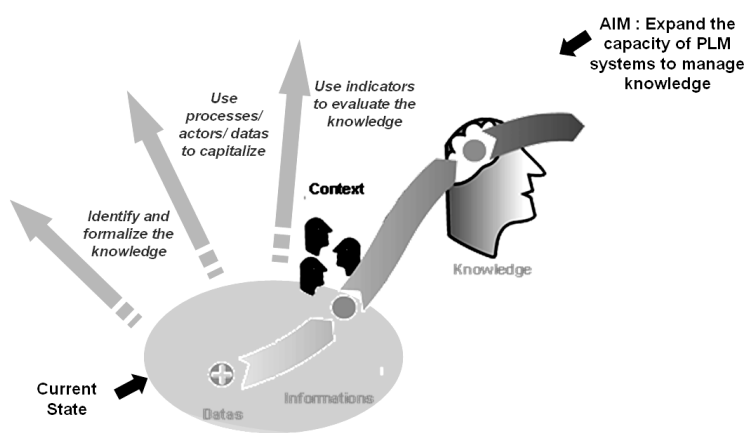

Figure 1. PLM system and knowledge

The objective of this paper is to study product lifecycle information systems within the contex of a knowledge capitalization. We wish to propose more particularly a methodology which allows the knowledge integration around a system PLM.

The industrial context of this work lies in the industrial sector in the plastics industry. In this industry, the needs involving the optimization and the development of products are quintessential. Indeed, the plastic manufacturing context is made of many small and medium-sized firms operating in a highly competitive sector.

The Marmillon SAS company involved in this work is our industrial partner. This company develops and manufactures plastic parts for the automotive industry. To respond to changes in its external environment and as a result of internal findings, the company has chosen to remain competitive by focusing on two areas of progress:

- optimize the development of new products,
- propose request for quotation adjusted to score on a reactive basis.

First we present the context of knowledge capitalization and business process modelling (BPM). Then we present our methodological approach for knowledge integration in PLM systems. Lastly, we present the setting works with an industrial case in the plastic manufacturing.

2 KWNOLEDGE CAPITALISATION CONTEXT

2 1 Needs of corporate memories

Knowledge contributes to the preservation of the know how of the company. The corporate memory explicitly represents the company's information and knowledge [1]. It constitutes also the company's resources implemented by knowledge and collective data [2].

This knowledge is interlinked with various elements handled within the company's activity such as products, customers, marketing strategies, the expertise stemmed from projects.

The exploited knowledge within a medium-sized company can concern several elements treated within an activity such as products, design and production processes, return on experience on the projects, expertise resulted from these projects. Supports of these collections can take various forms as databases, electronic documents, reports, breviaries of knowledge, descriptive index cards. Companies have difficulties to choose methods to well capitalize and protect their knowledge.

The need to establish corporate memories is justified by the re-use of knowledge, reasoning and behavior. This aim meet those of the PLM systems. Indeed products life cycle management promotes the know-how re-using. In companies where innovation is the incremental process, mastering its know- how enables the increase of innovation capacity as well as the decrease of the products development time.

2 2 Capitalisation methods

The re-using of knowledge requires that enterprises are able to formalize it. From a general viewpoint the existing approaches coincide with knowledge life cycle defined by Grundstein.

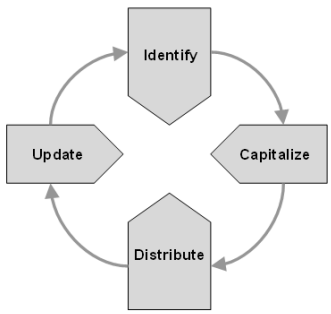

Figure 2. Extract of knowledge lifecycle

Methodologies from the knowledge engineering [3] aim at proposing a framework with methods to preserve and serve as a base for the knowledge formalization. Several methodologies exist: methods based on interviews (KOD Knowledge Oriented Design), methods of knowledge capitalization (REX and MEREX [4]), and methods of structured acquisition (MSKM [5] [6] [7]).

The knowledge formalization allows to assure a coherence and an exploitation of knowledge bases. There are various formalisms of knowledge representation. The use of graphs to represent knowledge is usual [8] [9]. Graphs are used to abstract the relevant information and concentrate only on the topology of a problem.

With the Conceptual Graph (CG), Sowa [10] proposes a generic formalism for any type of representation of the knowledge. The meaning of a concept is reduced to its relative position according to the other concepts. It thus takes a sense only if a semantic network modelling the general knowledge of the system exists.

Furthermore, ontologies allow to specify a conceptualization of a specific domain of knowledge [11]. They present the advantage to propose a formal description which constitutes a structured set by concepts allowing to give sense to the information. The concepts are organized in a graph whose relations may be represented by semantic relations or relations of subsomption.

Even if they are not used in link with PLM systems, the ontologies or the abstract graphs allow to describe numerous concepts to be implemented in the PLM [12]: individuals; classes sets(for types of objects), attributes (characteristics of the object), relations (the way objects are bound), events (relations change or attributes). It is thus possible to transcribe (in a PLM compatible format) a part of the knowledge formalized with these representations [13].

For companies, the question is how to define an information system that is the most adapted to capitalize knowledge. In a lot of companies, the information system is composed of heterogeneous components covering all sectors of the company. Each element covers a particular function (ERP, PLM, SCM, CRM). In this context, the manufacturing management (ERP), the management of the customer relation software (CRM) and the supply chain management software (SCM) are aiming to optimize the information flow linked to the products and traks. These applications are designed to optimize repetitive operations and are especially effective to handle processes which appeal to the same task. The PLM is defined as: "an organizational device allowing to regulate the creation, the traffic, the use and the evolution of the informative heritage of definition of the product, that is all the information which define how the product is designed, made and used " [14]. These systems are thus in theory the most capable to take care of the totality of the product development process [15] [16]. Actually, PLM systems have an implicit vocation to capitalize the know-how.

3 CONTEXT OF BUSINESS PROCESS MANAGEMENT

The BPM (Business Process Management) has been managing the companies' businesses processes for several years. Despite the increasing number of tools, implementation remains delicate for several reasons : impact on organizations, reluctance to change, scope and granularity of the process. Whatever the difficulties are, a BPM approach is always in line with a company's rationalization process exactly as the implementation of a PLM system. This is the reason why we choose to link theses approaches described in the following paragraphs.

Processes representation models are commonly used in companies. Traditionally, we find the approaches around IDEFX, SADT, etc.... Even if these models are often used to represent processes, they have shown their limits with less structured or progressive processes, but above all, they do not allow execution. Approaches around the WfMc's Workflows are suggesting to model and run these processes by means of a runtime software. These different models are generic and can

go from the business representation to the instantiation in the information system. In fact they are poorly adapted for implementation in the scope of the companies industrial tools like PLM or ERP.

4 INTEGRATION APPROACH WITHIN PLM SYSTEMS

4 1 Global approach

A PLM system can be represented by the figure 3.

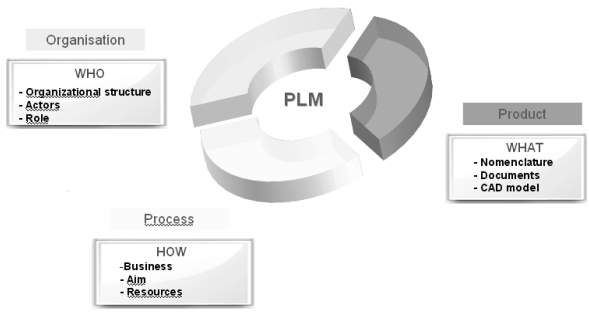

Figure 3. The three components of a PLM system

Our goal is to integrate and capitalize the knowledge generated by a process into a PLM system. Our approach (figure 4) is devided in two phases: *process integration* and *knowledge integration*.

These two steps are described in next sections.

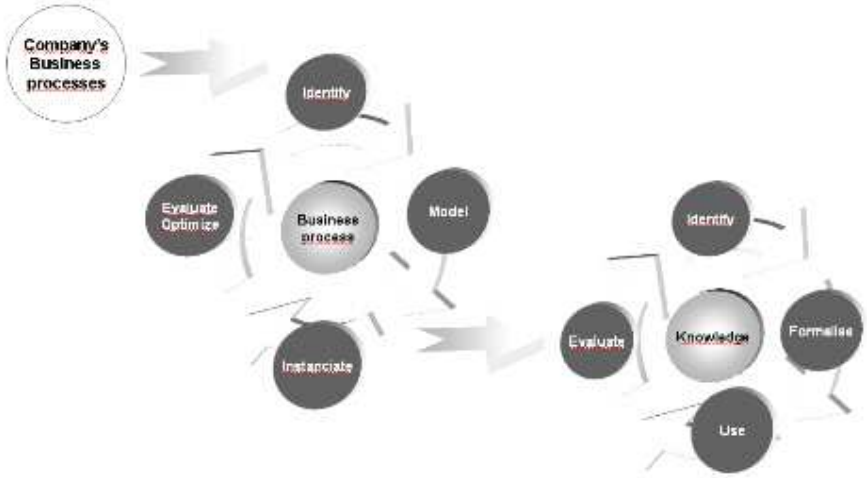

Figure 4. Global approach to BP and Knowledge integration

4 2 Business Process integration within a PLM system

The business processes integration in the PLM system is the first step in our approach. PLM systems can build validation circuits and tasks to achieve between the various actors in a process. Currently, PLM processes are focused on the life cycle and not on activities. This point can not allowes processes instantiation with tools such as BPMN, XPDL or BPML.

Our approach (figure 5) is composed of four stages: identification, modeling, instanciation, and evaluation.

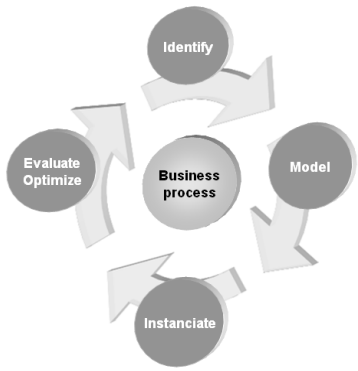

Figure 5. BP integration

Identification: from the tasks / activities identified in business processes, this step is to identify classes of objects as well as their state periphery. Peripheries statements define the life cycles of objects. The purpose of this step is to get the product model in the PLM.

Modelling: within the PLM systems, processes modelling is made by means of workflows centred on the life cycle. From the previous identification, the processes are restructured into executable elements (usine BPML model for instance).

Instantiation: once processes modelling achieved within the PLM system, processes are instantiated and used by users. This step of use takes place continuously and activities tracks generated by the system are used for assessment.

Evaluation : In order to integrate business processes and evaluate them within a PLM system, we propose a typology of processes with associated indicators. The objective is to evaluate them at the time of their execution by the PLM system.

There are different approach to caracterize processes: approach based on activities, on the types of inputs / outputs or on the degree of structuring. The typology of indicators suggested in this paper is based on a decomposition following four criteria: *time base* (limited process, cyclical,...),

stability (stable process, evolutionary, unstable), *genericity* (single instance, multiple instances), *measurability* (measurable process, un-measurable).

4 3 Knowledge integration within a PLM system

From the process modelling in the system, the second major step is to integrate elements of knowledge in the PLM system. The aim is to allow a knowledge capitalization from the process activities to expand PLM system capacities to manage knowledge. In the context of the knowledge lifecycle, the main steps (Grundstein) are identified by different stages as shown in figure 6:

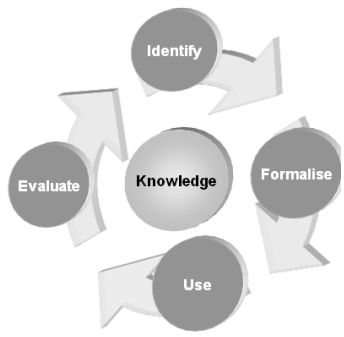

Figure 6. Knowledge integration

- *Identify* : *identification of knowledge to build up a PLM system*. This step is to identify more precisely elements of knowledge to be manage within the PLM system. The modelling design should lead a data model which could be instantiated in the PLM system. UML class diagrams can be used to model objects and links between them.

Identification of business rules: this step is to identify behavioral rules that will directly depend on identified objects in the previous stage.

- *Formalise* : it is necessary to create convertion rules in XML to use knowledge in the system. Formalization aims at transforming conceptual graphs models (if CG models choosen) in order to integrate them into the PLM system.
- *Use* : the PLM system framework includes a presentation server and an application server that are communicating with a data base as shown in figure 7. As seen previously, the information system designer will have to identify knowledge and set up the mapping in order to use it within the system. The user gets access to knowledge objects, rated by indicators, through the system interface.

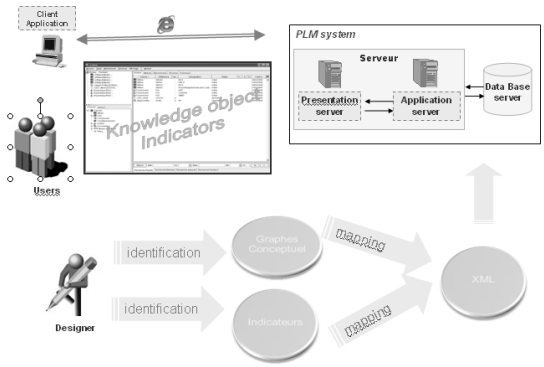

Figure 7. Use of the PLM system

- *Evaluate* : this step allows to evaluate the use of objects identified in previous stages. We propose to define indicators using the traceability systems in PLM. These indicators are designed to trace the activities use of objects (access, research, modifications…).

5 INDUSTRIAL CASE

As specified previously, the industrial application is in the field of plastics manufacturing within Marmillon SAS company. The aim of a PLM system deployment in this company is to optimize the product development process.

The company's business is based on responses to request for quotation. However, we note that this request for quotation process is failing. Today, the response time to the customer as well as the acceptance rate of products cost estimation is not in accordance with strategic requirements. For these reasons, we chose to focus our analysis on this business process and knowledge it manages.

Based *on business process integration steps* (see figure 5 and paragarphe 4.2, identification and modelling steps), we were able to identify the product model and its the status as shown in figure 8.

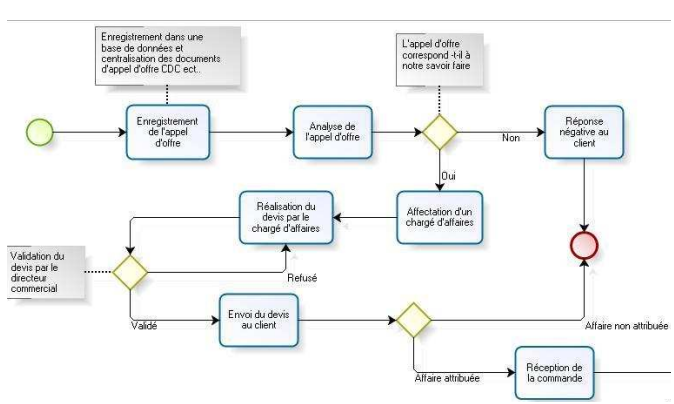

Figure 8. Example of processes using BPMN

The resulting model (Figure 9) is instantiable in the meta-model solution Audros.

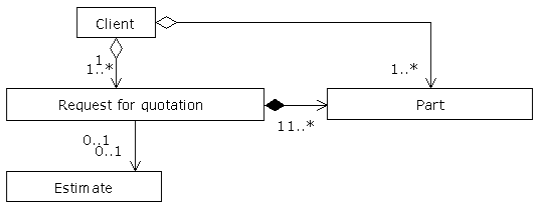

Figure 9. Extract of product model (Class Diagram)

Based on knowledge integration, the second step allows to classify information managed during the offer treatment in several categories. Objects (RfQ, Part) contain three types of information:

- parameters such as margins, hourly rates which fluctuate according to the situation
- rates providers such as the material price, shipping prices which are regularly updated
- estimations such as purchase price of the mold, number of working hours of the research department. These estimations depend on the part characteristics.

Knowledge to capitalize falls into this third category called "estimations". Indeed, these cost estimations made by the person in charge of this task require significant expertise and knowledge trade. In this expertise, the mold made by a subcontractor of the company is a very important element. The mold also depends on the characteristics of the part to be manufactured as shown in figure 10.

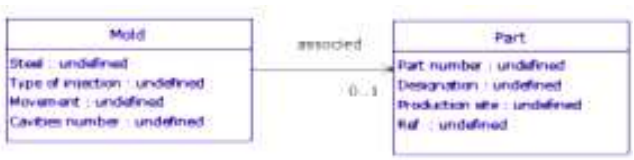

Figure 10. Part and mold properties (Class Diagramm)

To complete the identification step of knowledge integration, identified elements of knowledge must be formalized within the PLM system. These elements are: the cost estimation, the mould, the part, the estimation interface. This last object is going to contain the calculation rules based on mold parameters and and part characteristics.

Furthermore, the use case (figure 11) of this estimation allows to identify the skill of different actors (realization of cost estimations, validation estimation).

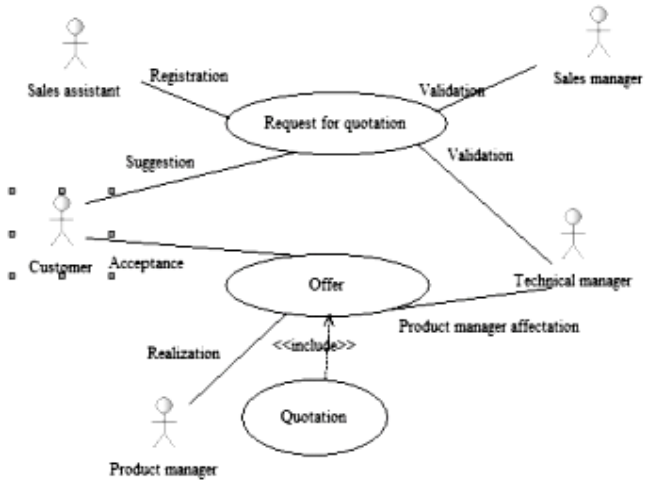

Figure 11. use case for request for quotation

From the knowledge identification, we must define business rules. We propose a set of predicates for one of identified objects. Here is an example of a rule that can be identified: "If type of part = , if weight = 10g, if cavities number = 3, if type of steel = tempered steel, then purchase price is between X € and Y €".

Indicators will estimate knowledge to know its reliability. In the previous example, we want to know if the mold estimated price for this part is reliable. It will therefore establish a quantitative indicator between the estimated purchase price and the actual purchase price. The information quoted by a quantitative indicator is to be weighed. The work on knowlege indicators is still in progress.

The following diagramm shows the link between the different elements identified within each step of our approach.

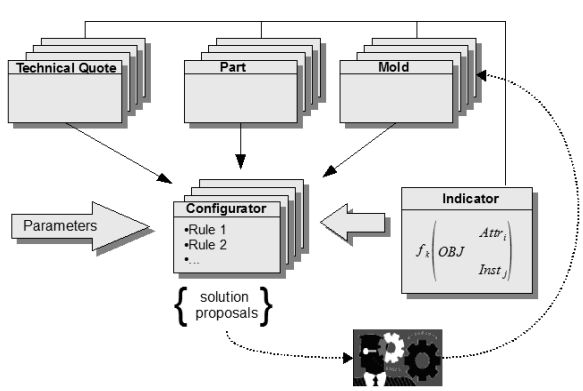

Figure 12. Knowledge integration

6 CONCLUSION

Through an industrial example, we show the possibilities of a knowledge capitalization approach within a PLM system. The aim is to use capabilities of structuring and traceability of these systems to build and supply elements of knowledge on products development. The proposed approach aims at showing that crutial knowledge can be extract from processes modelling easily useful by people who are not knowledge engineers.

PLM systems presents two advantages for knowledge management:

The first point concerns the extension of meta-models to model entities related to technical knowledge.

The second point concerns the management track that allows the establishment of indicators to evaluate this knowledge. However, it seems difficult to provide funding methods and tools for the generation of knowledge.

The areas for improvement and validation remain steps upstream and downstream of construction business wokflows ie the identification of knowledge and indicators to evaluate them.

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